

5.12.4 Conclusions

Detailed chemical analysis of soil samples at the Watery Oil Separator (SWMU 43) did not detect VOCs or BNAs in the surface and subsurface zones in excess of RBSLs with the exception of methylene chloride, which was detected in subsurface soil at a level slightly in excess of its migration to groundwater RBSL at location 43-03. Methylene chloride, a common laboratory contaminant, was not detected above RBSLs at any other location and was not detected in groundwater samples at the Watery Oil Separator.

Arsenic was detected in soil at three locations at concentrations in excess of its direct contact RBSL. At one location, the concentration was slightly above the arsenic background levels at the site. At the other two locations, the concentrations were below background levels of arsenic. A number of other metals were detected in the surface and subsurface zones, but all at concentrations below RBSLs.

Detailed chemical analysis of the groundwater samples collected at the Watery Oil Separator did not detect VOCs, BNAs, or metals in groundwater at concentrations in excess of groundwater screening levels.

A localized FPH plume was detected on the water table at the Watery Oil Separator during implementation of the RFI in 1996 and 1997. With the installation of wells WOS-4A and WOS-5, the FPH plume has been fully delineated. FPH is routinely monitored and recovered as part of a site-wide interim corrective measure being implemented at the SCYI facility. Historical product thickness measurements indicate that the FPH plume is not migrating and is therefore stable. Groundwater sampling results demonstrate that groundwater at the WOS has not been impacted by dissolution of the FPH.

As previously mentioned, the surface soil at location 43-03 was not sampled for BNAs and metals. Since the surface soil results for VOCs and the boring log at this location did not indicate any impact to soil quality, the change in sampling did not affect the overall contamination assessment. The BNA and metal results from a subsurface sample collected at 3-3.5 ft at location 43-03, which is somewhat representative of surface soil, did not show any

exceedances of RBSLs. Additionally, the localized FPH plume at the SWMU would likely pose the greatest impact. However, as discussed above, no significant impact to soil or groundwater was indicated. The general area is also covered with a concrete pad.

The results of the RFI at the Watery Oil Separator demonstrate that soil and groundwater in the area have not been significantly impacted by operation of the unit or dissolution of the FPH plume. No further investigation is warranted at this unit. However, interim measures consisting of FPH measurement and recovery will continue at the unit.

5.13 Ballast Basin Skimmer Area (SWMU 44)

The objective of the field investigation at the Ballast Basin Skimmer Area was to determine if the soil in the vicinity of the unit is contaminated with petroleum hydrocarbons or MSL metals and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

5.13.1 Scope of Work

Soil Investigation

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at five locations identified as 44-01 through 44-05 as shown in Figure 5-21. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the field investigation. Soil sampling was conducted in June and August 1996.

A total of 17 soil samples were collected from 0 to 7.0 ft bgl for various chemical analyses at the five soil borings. Immunoassay field screening was performed on a total of 13 soil samples from five boring locations for BTEX and/or PAHs. Detailed chemical analysis for TCL VOCs, BNAs, and/or MSL metals was performed on samples collected from two depth intervals from location 44-01 and two depth intervals from location 44-03 to characterize the surface and subsurface soil horizons.

Groundwater Investigation

A groundwater sample was collected from existing monitoring well BB-2 as shown in Figure 5-22 and analyzed for VOCs, BNAs and dissolved metals. The groundwater sample was collected in August 1996.

5.13.2 Site-Specific Geology and Hydrogeology

The subsurface soil at the Ballast Basin Skimmer Area generally consists of sand and silty clay to a depth of approximately 4.0 ft bgl followed by sand to a depth of 9.5 ft bgl. The results of the physiochemical descriptions and the grain size distribution graphs are included in Appendix H. Groundwater was encountered at approximately 7.5 ft bgl in boring 44-03. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 44 is to the east.

5.13.3 Results

Soil Investigation

The results of the laboratory analysis for VOCs are presented in Tables 5-89 and 5-90 for surface and subsurface soil, respectively, and summarized in Figure 5-21. Acetone was detected in the subsurface zone at locations 44-01 and 44-03, but at concentrations below RBSLs. Acetone is a common laboratory contaminant. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Tables 5-91 and 5-92 for surface and subsurface soil, respectively, and summarized in Figure 5-21. The laboratory identified only 2-methylnaphthalene and naphthalene at various locations and depths, but at concentrations below RBSLs. No other BNAs were detected.

The results of the laboratory analysis for metals are presented in Tables 5-93 and 5-94 for surface and subsurface soil, respectively, and summarized in Figure 5-21. Arsenic was detected at a level in excess of its direct contact RBSL of 1.6 mg/kg in subsurface soil at location 44-03 (6.5-7 ft bgl) at an estimated concentration of 5.5 J mg/kg. However, this level is below the site soil background level for arsenic of 8.7 mg/kg. Barium, beryllium, chromium, mercury, nickel, cobalt, lead and vanadium were also detected at various locations and depths, but at concentrations less than RBSLs.

No staining or residual petroleum product was observed in any of the borings drilled at the Ballast Basin Skimmer Area. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-98. BTEX was identified at levels ranging from non-detect to greater than 35 ppm; no PAHs were detected in any samples.

Groundwater Investigation

The results of the laboratory analysis of the groundwater sample from well BB-2 for VOCs, BNAs and metals are presented in Tables 5-95, 5-96, and 5-97 and summarized in Figure 5-22. No VOCs or BNAs were detected in the groundwater sample with the exception of acetone, a common laboratory contaminant, which was detected at a level below groundwater screening levels. The laboratory identified barium, cadmium, cobalt and chromium in the sample, but all at levels less than screening levels.

5.13.4 Conclusions

Detailed chemical analysis of soil samples at the Ballast Basin Skimmer Area did not detect VOCs or BNAs in the surface and subsurface zones in excess of RBSLs. Arsenic was detected at one location at a concentration in excess of its direct contact RBSL. However, this concentration is below background levels of arsenic found at the site. A number of other metals were detected in the surface and subsurface zones, but all at concentrations below RBSLs.

Detailed chemical analysis of the groundwater sample collected at the Ballast Basin Skimmer Area did not detect VOCs, BNAs, or metals in groundwater at concentrations in excess of groundwater screening levels.

The results of the RFI sampling program at the Ballast Basin Skimmer Area demonstrate that operation of the unit has not impacted soil or groundwater in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.

5.14 Ballast Basin Leachate Collection Tank (SWMU 44A)

The objective of the field investigation at the Ballast Basin Leachate Collection Tank was to assess the structural integrity of the tank. This was done to determine if there was any visual evidence that the leachate collection tank has released hazardous constituents to subsurface soils.. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

5.14.1 Scope of Work

A detailed visual inspection of the interior of the Ballast Basin Leachate Collection Tank was conducted. The objective of the inspection was to evaluate the structural integrity of the tank and to assess the potential for the migration of accumulated liquids from the tank into surrounding soils. The inspection was conducted from above ground using artificial lighting due to limited access through the 12-inch hatch on the tank cover. Visibility was adequate to thoroughly inspect the interior of the tank and to successfully evaluate the tank's integrity. The location of the Ballast Basin Leachate Collection Tank is presented in Figure 5-23.

As per the provisions of the RFI Work Plan, no soil or groundwater sampling was conducted at this unit.

5.14.2 Results of Visual Inspection

The tank consists of a vertically oriented 42-inch diameter concrete pipe resting on a 6-inch thick reinforced concrete slab. The depth of the tank was measured at 9 ft 7 in from the top of the tank cover to the top of the slab. A 4-inch PVC pipe enters the tank from the south at a point approximately 12 inches from the tank bottom. At the time of the inspection, the tank contained an accumulation of water to a depth of 30 inches. The standing water was quiescent and clear and did not interfere with visual observation of all features of the tank.

The interior surface of the tank was observed to be free of significant corrosion, cracking or structural defects with only minor spalling of the concrete surface. There was no visual evidence

of displacement, settling or other movement of the tank that could result in releases from the unit. Grout around the base of the tank as well as grout around the 4-inch PVC pipe was noted to be in good condition with little evidence of deterioration. The pattern of stains on the interior surface of the tank suggests an historical downward migration of rainwater entering the tank through seams at the cover.

5.14.3 Discussion

Visual inspection of the Ballast Basin Leachate Collection Tank found no evidence of structural defects or other conditions that could result in a release of accumulated liquids into the subsurface. Liquid contained in the tank at the time of the inspection appeared to be accumulated precipitation that had entered through seams at the tank cover.

As discussed in the RFI Description of Current Conditions Report (AMAI, 1994a), a water sample was collected from the unit in January 1992 and analyzed for TCL VOCs, BNAs, and MSL metals. The sample results showed that no VOCs or BNAs were detected, with the exception of a trace level of acetone, a common laboratory contaminant. No metals were detected. This shows that the water within the tank, which was likely from rainwater, was free of contaminants.

5.15 East Aisle Ditch (SWMU 45)

The objective of the RFI field investigation at the East Aisle Ditch was to determine if the soil in the vicinity of the ditch is contaminated with petroleum hydrocarbons or MSL metals and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

5.15.1 Scope of Work

Soil Investigation

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at 12 locations identified as 45-01 through 45-12 as shown in Figure 5-24. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analysis for VOCs, BNAs, and/or metals was used in the field investigation. Soil samples were collected in June and July 1996.

A total of 35 soil samples were collected from 0 to 5.5 ft bgl for various chemical analyses from the 12 soil borings. Immunoassay field screening was performed on a total of 21 soil samples from 12 boring locations for BTEX and/or PAHs. Detailed chemical analysis for VOCs, BNAs and/or metals was performed on soil samples collected from one depth interval from locations 45-01, 45-02, 45-06, 45-09, 45-10, 45-11, and 45-12, two depth intervals from 45-04 and 45-08, and three depth intervals from 45-05 to characterize the surface and subsurface soil horizons.

Groundwater Investigation

Although not required in the Work Plan, four shallow groundwater monitoring wells were installed at locations 45-01, 45-02, 45-09 and 45-10 as shown in Figure 5-25 to determine the extent of FPH, if any, on the water table surface, to characterize groundwater quality in the area, and to observe groundwater levels. A groundwater sample was collected from each of the four

monitoring wells and analyzed for VOCs, BNAs and dissolved metals. The wells were installed in June and July 1996 and sampled in February 2003.

5.15.2 Site-Specific Geology and Hydrogeology

The subsurface soil at the East Aisle Ditch typically consists of sand to a depth of approximately 6 ft bgl. Groundwater was encountered during drilling at varying depths ranging from 1.5 ft bgl to 6.5 ft bgl. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 45 is to the east.

5.15.3 Results

Soil Investigation

The results of the laboratory analysis for VOCs in soil are presented in Tables 5-99 and 5-100 for surface and subsurface soil, respectively, and summarized in Figure 5-24. The laboratory identified acetone, methylene chloride and toluene at various locations and depths, but at concentration less than RBSLs. Acetone and methylene chloride are common laboratory contaminants. No other VOCs were detected.

The results of the laboratory analysis for BNAs in soil are presented in Tables 5-101 and 5-102 for surface and subsurface soil, respectively, and in Figure 5-24. The laboratory identified benzo(ghi)perylene, 2-methylnaphthalene, and phenanthrene at various locations and depths, but at concentrations less than RBSLs. No other BNAs were detected.

The results of the laboratory analysis for metals in soil are presented in Tables 5-103 and 5-104 for surface and subsurface soil, respectively, and summarized in Figure 5-24. Arsenic was detected at levels slightly in excess of its direct-contact RBSL of 1.6 mg/kg in surface soil at locations 45-01, 45-02, 45-04, 45-05, and 45-12 at concentrations ranging from 3.4 to 7.3 mg/kg, and in subsurface soil at locations 45-04 (3-3.5 ft bgl), 45-05 (3-3.5 and 5-5.5 ft bgl), 45-06 (5-5.5 ft bgl), 45-08 (3-3.5 ft bgl), and 45-09 (3-3.5 ft bgl) at concentrations ranging from 2.1 B to 4.7 mg/kg. However, these levels are below the site soil background level for arsenic of

8.7 mg/kg. Barium, beryllium, cadmium, chromium, mercury, nickel, cobalt, lead and vanadium were also detected at various locations and depths, but at concentrations less than RBSLs.

Apparent residual petroleum product was observed in the soil samples collected at locations 45-01, 45-06, 45-09 and 45-10. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-108. BTEX ranged from non-detect to greater than 35 ppm; PAHs ranged from non-detect to greater than 25 ppm.

Groundwater Investigation

The results of the laboratory analysis for VOCs in groundwater are presented in Table 5-105 and summarized in Figure 5-25. Acetone, a common laboratory contaminant, was detected at wells 45-01 and 45-02, but at concentrations below groundwater screening levels. No other VOCs were found in groundwater samples collected at this SWMU.

The results of the laboratory analysis for BNAs in groundwater are presented in Table 5-106 and summarized in Figure 5-25. The laboratory identified chrysene, fluorene, 2-methylnaphthalene, phenanthrene, and/or pyrene at wells 45-02, 45-09, and 45-10, but at concentrations less than groundwater screening levels.

The results of the laboratory analysis for metals in groundwater are presented in Table 5-107 and summarized in Figure 5-25. The laboratory identified barium, cobalt and/or vanadium in groundwater at all four wells, but all at levels less than groundwater screening levels.

Free Product Observations

Table 5-109 presents a summary of available FPH thickness measurements taken at monitoring wells at the East Aisle Ditch from August 1996 to April 2006. During the initial field investigation, an FPH sheen was observed at wells 45-01 and 45-10 in August 1996. A sheen was not subsequently observed at well 45-01, and only once additionally at well 45-10 in June 2002. A sheen was not initially reported at well 45-09, although a sheen has been observed at the well since September 2002. FPH has not been observed at well 45-02.

Figures 5-26A, 5-26B, and 5-26C, graphically present quarterly FPH measurement data at the East Aisle Ditch for 1997, 2001, and 2005, respectively. The locations of the monitoring wells are also shown in the figures. The FPH plume is stable. The measurements show that the extent of FPH has been defined at this SWMU and is limited to the immediate vicinity of the unit.

5.15.4 Conclusions

Detailed chemical analysis of soil samples at the East Aisle Ditch did not detect VOCs or BNAs in the surface and subsurface zones in excess of RBSLs. Arsenic was detected in soil at seven locations at concentrations in excess of its direct contact RBSL. However, these concentrations were below background levels of arsenic found at the site. A number of other metals were detected in the surface and subsurface zones, but all at concentrations below RBSLs.

Detailed chemical analysis of groundwater samples collected at four wells at the East Aisle Ditch API Separator did not detect VOCs, BNAs, or metals in groundwater at concentrations in excess of groundwater screening levels.

Localized FPH sheens were observed on the water table at wells 45-01 and 45-10 at the East Aisle Ditch during implementation of the RFI in 1996. FPH is routinely monitored and recovered at the East Aisle Ditch as part of a site-wide interim corrective measure being implemented at the SCYI facility. The FPH plume is stable. The measurements show that the extent of FPH has been defined at this SWMU and is limited to the immediate vicinity of the unit. Groundwater sampling results demonstrate that groundwater at the East Aisle Ditch has not been impacted by dissolution of the FPH.

The results of the RFI sampling program at the East Aisle Ditch demonstrate that soil and groundwater in the area have not been significantly impacted by operation of the unit. No further investigation is warranted at the East Aisle Ditch.

5.16 Main Dock Sump (SWMU 33)

The objective of the RFI field investigation at the Main Dock Sump was to determine if groundwater quality has been impacted by prior operations at the unit. This SWMU was included in the 1994 Consent Order due to the potential for impact to groundwater.

5.16.1 Scope of Work

In accordance with the procedures detailed in the RFI Work Plan, shallow groundwater monitoring wells were installed around the perimeter of the unit as shown in Figure 5-27. As part of the Work Plan, EPA required installation of wells at four locations (MDS-1 through MDS-4). In response to detection of free product at several of the wells, the monitoring well network was expanded to nine wells. Four additional wells (MDS-5 through MDS-8) were installed according to work plan addendums submitted to and approved by EPA. Additionally, well MDS-6R was installed for pumping test and other sampling purposes. Wells MDS-9R and MDS-10R were installed in March 1998 for groundwater depression and FPH recovery purposes as part of interim measure activities.

Groundwater samples were collected from wells MDS-3 and MDS-4 and analyzed for VOCs, BNAs and/or dissolved metals. A groundwater sample from well MDS-8 was analyzed for VOCs as specified in the work plan addendum. Samples were collected in August and September 1996. Because of the presence of FPH, monitoring wells MDS-1, MDS-2, MDS-5 and MDS-6 were not sampled. After the initial groundwater results were evaluated, a confirmatory sample and duplicate from well MDS-4 were collected in February 1997 and analyzed for VOCs. A sample of free product was collected from well MDS-6R for chemical fingerprint analysis.

An additional confirmatory groundwater sample was collected in June 2003 at well MDS-4 as part of the supplemental investigation and was analyzed for VOCs, BNAs and total and dissolved metals. The purpose was verify a benzene detection that occurred during the initial RFI in 1996. However, a pipeline release event on January 31, 2002, which was reported to EPA, resulted in FPH in well MDS-4. This release resulted in an additional benzene source.

In addition to the groundwater sampling conducted in accordance with the Supplemental RFI Work Plan, SCYI collected groundwater samples from groundwater depression wells MDS-9R and MDS-10R. Sampling of these wells, which was performed in June 2003, was intended to provide further assessment of potential groundwater impact in the area of the Main Dock Sump that may have resulted from dissolution of the FPH plume. Samples from wells MDS-9R and MDS-10R were collected from sampling ports located on respective effluent piping systems. The samples were analyzed for VOCs, BNAs and total and dissolved metals.

As part of initial RFI activities, well pumping tests were performed at wells MDS-3 and MDS-6R to observe the behavior of the aquifer under pumping conditions and to determine the aquifer hydrogeologic conditions. The data obtained from the pumping tests was considered in the preparation of the conceptual model of the facility as described in Section 2 of this report. During the pump tests, samples from well MDS-6R were analyzed for water quality parameters, and tidal measurements were also recorded in well MDS-8. Product baildown tests were also conducted.

Two surface water samples were collected from the Caribbean Sea Inlet located adjacent to the Main Dock Sump as shown in Figure 5-27. The objective of the sampling was to determine if surface water has been impacted by FPH releases observed in the vicinity of the Main Dock Sump. The scope of the surface water investigation was proposed to EPA in a letter dated February 14, 2005 and was approved by EPA on March 5, 2005.

Surface water samples were collected at two locations, MDS-SW1 and MDS-SW2, as shown on Figure 5-27. A duplicate sample was also collected at both locations. The samples were analyzed for VOCs and BNAs using SW-846 Methods 8260B and 8270C, respectively. The MDW-SW2 samples were also analyzed for MSL metals using CLP methods. The surface water samples were collected from the edge of the shoreline adjacent to the unit and collected directly into the sample bottles without any intermediate transfer devices. The samples were collected on February 23 and March 11, 2005.

In accordance with the Work Plan, no soil samples were collected at this SWMU.

5.16.2 Site-Specific Geology and Hydrogeology

The subsurface soil at the Main Dock Sump generally consists of topsoil to a depth of a few inches and sand to silty sand to a depth of approximately 25 ft bgl. Groundwater was encountered during drilling at varying depths ranging from 7.5 ft bgl to 10 ft bgl. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 33 is southward toward the Turning Basin.

5.16.3 Results

Groundwater Investigation

The results of the laboratory analysis for VOCs are presented in Table 5-110 and summarized in Figure 5-27. Benzene was detected in the 1996 sample from well MDS-4 at an estimated concentration of 9 J ug/L, which is in excess of its MCL of 5 ug/L. Since benzene, toluene and xylene were also detected in the field blank, suggesting that the detected concentrations may have been the result of field contamination, a confirmatory sample and duplicate were taken at well MDS-4 in February 1997 and analyzed for VOCs. The confirmatory sample and duplicate results showed non-detect for all VOCs, including benzene. The June 2003 supplemental sampling event again detected benzene at MDS-4 at concentrations in excess of its MCL of 5 ug/L at concentrations 48 ug/L in the primary sample and 60 ug/L in the duplicate sample. A release event, which occurred on January 31, 2002 and was reported to EPA, is the likely source of the elevated benzene level. Acetone, carbon disulfide, ethylbenzene, toluene, and xylene were also detected at various wells, but at concentrations less than groundwater screening levels.

The results of the laboratory analysis for BNAs are presented in Table 5-111 and summarized in Figure 5-27. Naphthalene and 2-methylnaphthalene were detected in excess of groundwater screening levels during the June 2003 sampling event. Naphthalene was detected at well MDS-4 in excess of its screening level of 6.2 ug/L at a concentration of 21.9 ug/L in both the primary and duplicate samples. At well MDS-4, 2-methylnaphthalene was detected in excess of its screening level of 24 ug/L at concentrations of 59.7 ug/L in the primary sample and 60.1 ug/L in the duplicate sample. Fluorene and phenanthrene were also detected at MDS-4, but at levels below

screening levels. A release event on January 31, 2002, which was mentioned above, is the likely source of the groundwater contaminants at well MDS-4. No other BNAs were detected by the laboratory in the groundwater samples collected at this SWMU. [It should be noted that the results at MDS-4 may be biased high due to the presence of a FPH sheen in the well prior to collecting the June 2003 groundwater sample. See Section 3 for a discussion on the sampling procedure at MDS-4 and other wells at which a FPH sheen was present.]

The results of metals analysis of groundwater samples collected at the Main Dock Sump are presented in Table 5-112 and summarized in Figure 5-27. In September 1996, dissolved arsenic was non-detect at well MDS-3, but detected at well MDS-4 at 5.3 B ug/L, which was slightly above the detection limit of 5.2 ug/L. In June 2003, arsenic (total and dissolved) was non-detect in the primary sample at well MDS-4, non-detect for dissolved arsenic in the duplicate, but detected at 3.5 B ug/L for total arsenic in the duplicate, which slightly exceeded the detection limit of 3.3 ug/L. Arsenic (4.3 B ug/L total, 5.4 ug/L dissolved) was detected at well MDS-9R. The arsenic levels at both wells MDS-4 and MDS-9R were below the MCL of 10 ug/L, however. Also, arsenic (total and dissolved) was non-detect at well MDS-10R. The laboratory also identified barium, beryllium, cadmium, chromium, cobalt, and vanadium at various wells, but all at levels less than the groundwater screening levels.

Free Product Observations

Table 5-113 presents a summary of available FPH thickness measurements taken at monitoring wells at the Main Dock Sump from July 1996 to April 2006. During the initial field investigation in July 1996 through January 1997, measurable FPH was observed at the Main Dock Sump at wells MDS-1, MDS-2, MDS-5, MDS-6, MDS-6R, MDS-7, and the large diameter well. Maximum reported apparent FPH thickness was 2.34 ft at MDS-6 as measured in August 1996. An FPH sheen was also observed at well MDS-4.

The most recent FPH measurements from April 2006 show measurable FPH at wells MDS-1, MDS-4, MDS-6, and MDS-10R, and a sheen at wells MDS-5, MDS-6R, MDS-9R, and the large diameter well. The maximum reported apparent FPH thickness was 0.2 ft at well MDS-6.

Figures 5-28A, 5-28B, and 5-28C, graphically present quarterly FPH measurement data at the Main Dock Sump (SWMU 33) for 1997, 2001, and 2005, respectively. The locations of the monitoring wells are also shown in the figures. The area that exhibited the greatest product thickness is near the southern boundary of the unit. The FPH plume is generally stable. Visual observations have been performed on a weekly basis at the shoreline opposite the Main Dock Sump since January 2001; no sheen has been observed. The extent of FPH has been defined at this SWMU.

Product baildown tests were conducted at wells MDS-1 and MDS-6 during the RFI to estimate the actual formation product thickness. The results, which are presented in Appendix I, showed estimated thicknesses for wells MDS-1 and MDS-6 of 0.2 ft and 0.15 ft, respectively. A product yield test conducted at the well indicated a very low recovery yield. Characterization of the free product at well MDS-6R by chemical fingerprinting showed a signature indicative of severely degraded topped fraction of a crude oil. The specific gravity of the product was determined to be 0.87. The free product characterization results are presented in Appendix I.

Surface Water Investigation

The results of the laboratory analysis for VOCs, BNAs, and metals in surface water are presented in Tables 5-114, 5-115 and 5-116. No VOCs or BNAs were detected in the samples. Barium, selenium, and vanadium were detected in the primary and/or duplicate sample from MDS-SW2, but at levels below screening levels.

Arsenic (2.7 B ug/L) was detected in the primary sample at location MDS-SW2, which is above its human health screening level (fish consumption) of 1.4 ug/L (reference Section 5.1.2).

Arsenic was not detected in the duplicate sample, however. The arsenic detection may be due to instrument noise near the detection limit since the detected level of 2.7 B ug/L is close to its detection limit of 2.2 ug/L, and also since it was only detected in the primary sample, but not the duplicate sample. Arsenic occurs naturally in seawater in concentrations generally ranging from 1 to 2 ug/L (WHO, 2001). Turekian (1968, pg. 92, Table 6-1 entitled "The Composition of Sea Water at 35% Salinity") reports an arsenic level of 2.6 ug/L for seawater. Therefore, the arsenic level detected in the surface water at the shoreline adjacent to the Main Dock Sump may also be

due to natural background levels of arsenic in seawater. Additionally, groundwater sampling results for arsenic at the Main Dock Sump do not show any elevated levels. Overall soil sampling results for arsenic from the RFI also do not indicate elevated levels. The groundwater and soil sampling results, together with knowledge of site process characteristics, do not appear to show any evidence of an arsenic release at the facility.

5.16.4 Conclusions

A localized FPH plume was detected on the water table at the Main Dock Sump during implementation of the RFI. The FPH plume has been fully delineated. FPH is routinely monitored and recovered as part of a site-wide interim corrective measure being implemented at the SCYI facility. FPH plume delineation is based on measurement of monitoring of FPH thickness in monitoring wells as well as routine inspection of downgradient surface water for FPH (which has never been observed). Historical product thickness measurements and surface water observations indicate that the FPH plume is not migrating and is therefore stable.

RFI groundwater sampling results at the MDS identified a localized area of potentially impacted groundwater at MDS-4 with benzene, naphthalene, and 2-methylnaphthalene concentrations in excess of groundwater screening levels. Since naphthalene and 2-methylnaphthalene had not been previously detected at MDS-4 and benzene had been tentatively detected, and not confirmed, at a much lower concentration than that reported in 2003, it is likely that a January 31, 2002 hydrocarbon release at the Main Dock Sump contributed to the FPH impact at MDS-4. As initially reported to EPA in February 2003, the incident involved a release of product from the Main Dock Pipeline to the soil adjacent to MDS-4. FPH was observed in the well for the first time after the incident. On February 6, 2003, a report was submitted to EPA summarizing the spill event and SCYI's response activities.

Benzene, naphthalene, and 2-methylnaphthalene results of June 2003 may be biased high due to the presence of an FPH sheen in well MDS-4 prior to sample collection. Although the sheen was removed prior to sampling, the elevated results may be attributed to cross-contamination and may not be representative of actual groundwater quality in the area. Follow-on groundwater sampling

is being conducted at well MDS-4 on a quarterly basis in order to confirm the presence or absence of these constituents in groundwater at MDS-4.

Sampling of the two groundwater depression wells (MDS-9R and MDS-10R) located downgradient of the Main Dock Sump indicate no impact to groundwater above screening levels during pumping conditions. Additionally, total dissolved solids (TDS) and specific conductivity (SC) results at the wells during the sampling indicates that the groundwater in the area of the unit is not potable (TDS of 20,700 mg/L and SC of 31,900 uS/cm at well MDS-9R, and TDS of 22,700 mg/L and SC of 33,000 uS/cm at well MDS-10R).

The groundwater depression pumping system at the Main Dock Sump was shut down in May 2004 as a result of an EPA Water Programs Branch instruction to cease discharge of the pump effluent to the facility wastewater treatment plant. EPA's rationale was that the effluent discharge is not covered under the facility's National Pollution Discharge Elimination System (NPDES) permit. The facility notified EPA of this situation in a letter dated September 14, 2004. As discussed in the letter, the facility will continue the interim measures weekly FPH recovery schedule at the unit, with the modification that the groundwater depression pumps will not be employed. Also, as discussed in the letter, the cessation of groundwater depression pumping does not appear to have affected the effectiveness of the FPH recovery. Detailed remedial options for the Main Dock Sump will be evaluated as part of the Corrective Measures Study.

The groundwater flow direction at the Main Dock Sump indicates groundwater discharges to the adjacent surface water (seawater) of the Turning Basin. However, the results of the investigation demonstrate that there is no impact to this surface water by FPH releases in the vicinity of the unit. Since no adverse impact to the surface water is indicated, by inference, the impacted groundwater has been fully delineated.

Other than additional groundwater sampling at MDS-4, and continued FPH measurement and recovery as part of interim measures, no further investigation or delineation of groundwater quality is warranted at the Main Dock Sump. Sediment sampling at the shoreline adjacent to the unit, as required by the facility's RCRA permit, will be performed as part of the Corrective Measures Study at the unit.

5.17 Barge Dock Sump (SWMU 34)

The objective of the field investigation at the Barge Dock Sump was to determine if the soil in the vicinity of the unit is contaminated with petroleum hydrocarbons or MSL metals and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

5.17.1 Scope of Work

Soil Investigation

Soil and groundwater sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at eight locations identified as 34-01 through 34-08 as shown in Figure 5-30. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analysis for VOCs, BNAs, and/or metals was used in the field investigation. Soil sampling was conducted in June through August 1996.

A total of 20 soil samples were collected from 0 to 8.0 ft bgl for various chemical analyses and other physiochemical descriptions from the eight locations. Immunoassay field screening was performed on a total of 12 samples from five locations for BTEX and PAHs. Detailed chemical analysis for VOCs, BNAs, and/or metals was performed on samples collected from two depth intervals at location 34-02 and from one depth interval at locations 34-04, 34-05, 34-06, 34-07, and 34-08 to characterize the surface and subsurface soil horizons. In addition, one sample was collected from location 34-03 and analyzed for physiochemical parameters.

Groundwater Investigation

Seven shallow groundwater monitoring wells identified as BDS-1 through BDS-7 were installed to the north, south and east of the Barge Dock Sump in order to collect groundwater samples for chemical analyses, to observe groundwater levels, and to delineate any FPH in the area. The

locations of the wells are presented in Figure 5-31. The wells were installed in June through August 1996.

Groundwater samples were collected from the seven monitoring wells in August and September 1996. Samples from locations BDS-1 and BDS-2 were analyzed for VOCs, BNAs, and dissolved metals. Samples from locations BDS-4, BDS-5, BDS-6, and BDS-7 were analyzed for VOCs only. Well BDS-3 was not sampled because of the presence of free product. Existing well MW-1 was also sampled and analyzed for VOCs. After the initial groundwater results were evaluated, confirmatory samples from wells BDS-4 and BDS-5 were collected in February 1997 and analyzed for VOCs. A confirmatory sample and duplicate were also collected from well BDS-2 and analyzed for dissolved arsenic. A sample of free product was collected from well BDS-3 for chemical fingerprint analysis. Product baildown tests were conducted to estimate the formation product thickness. Tidal measurements were recorded at BDS-1 and at upgradient well DA-1 to evaluate the influence of tidal effects on groundwater flow.

In April 2003 as part of the supplemental investigation, groundwater samples were collected at wells BDS-2, BDS-4 and BDS-5. Samples from all three wells were analyzed for VOCs. The sample from well BDS-2 was also analyzed for total and dissolved arsenic. The objectives of the supplemental sampling were to determine whether previously-detected benzene and arsenic are present in groundwater at levels in excess of groundwater screening levels.

5.17.2 Site-Specific Geology and Hydrogeology

The subsurface soil at the Barge Dock Sump generally consists of sand to silty sand to a depth of approximately 16 ft bgl. Locally, a gravelly silty sand was encountered to a depth of 4 ft bgl. Groundwater was encountered during drilling at varying depths ranging from 4.5 ft bgl to 8.5 ft bgl. Based on the site-wide groundwater level map presented in Figures 2-16 and 2-17, the direction of groundwater flow at the Barge Dock Sump is eastward toward the Turning Basin.

5.17.3 Results

Soil Investigation

The results of the laboratory analysis for VOCs are presented in Tables 5-117 and 5-118 for surface and subsurface soil, respectively, and summarized in Figure 5-30. The laboratory identified toluene and xylene in the surface zone at location 34-02 and acetone in subsurface soil at location 34-08, but all at concentrations less than RBSLs. Acetone is a common laboratory contaminant. No other VOCs were detected although elevated detection limits occurred for the samples from 34-04, 34-05, and 34-06.

The results of the laboratory analysis for BNAs are presented in Tables 5-119 and 5-120 for surface and subsurface soil, respectively, and summarized in Figure 5-30. The laboratory detected 2-methylnaphthalene in subsurface soil at locations 34-04 (110,000 D ug/kg), 34-05 (35,000 D ug/kg), and 34-06 (31,000 D ug/kg) (all at a depth of 7.5–8 ft bgl) at a concentrations which exceed its migration to groundwater RBSL of 17,000 ug/kg. The laboratory also identified chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene in the subsurface soil at various locations, but all at concentrations less than RBSLs. No other BNAs were detected.

The results of the laboratory analysis for metals are presented in Tables 5-121 and 5-122 for surface and subsurface soil, respectively, and summarized in Figure 5-30. Arsenic was detected at levels in excess of its direct-contact RBSL of 1.6 mg/kg in surface soil at location 34-02 (4.1 J mg/kg), and in subsurface soil at locations 34-02 (3-3.5 ft bgl), 34-05 (7.5-8 ft bgl), 34-06 (7.5-8 ft bgl), 34-07 (4.5-5 ft bgl), and 34-08 (4-4.5 ft bgl) at concentrations ranging from 2.7 J to 6.1 J mg/kg. However, the levels are below the site soil background level for arsenic of 8.7 mg/kg. The laboratory also identified beryllium, chromium, cobalt, lead, nickel, and vanadium at various depths and locations, but all at concentrations less than RBSLs.

Staining and/or apparent residual petroleum product was observed at a number of drilling locations near the Barge Dock Sump. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-126. BTEX ranged from non-detect to greater than 35 ppm; PAHs ranged from non-detect to greater than 25 ppm.

Groundwater Investigation

The results of the laboratory analysis for VOCs in groundwater are presented in Table 5-123 and summarized in Figure 5-31. The laboratory identified ethylbenzene, toluene and/or xylene in the initial samples collected from monitoring wells BDS-2, BDS-4 and BDS-6 at concentrations less than groundwater screening levels. Benzene was detected at a level slightly exceeding its MCL of 5 ug/L in monitoring well BDS-4 at a concentration of 6 J ug/L. Since benzene, toluene and xylene were also detected in the field blank, suggesting that the detected concentrations may have been the result of field contamination, confirmatory samples were taken at wells BDS-4 and BDS-5 and analyzed for VOCs. The 1997 confirmatory sample results showed non-detect for all VOCs, including benzene. Analysis of samples collected from the three wells in April 2003 as part of the supplemental investigation did not detect VOCs above screening levels.

The results of the laboratory analysis for BNAs are presented in Table 5-124 and summarized in Figure 5-31. The laboratory identified 2-methylnaphthalene and phenanthrene in a sample collected from well BDS-2, but at levels less than screening levels. No other BNAs were detected.

The results of the laboratory analysis for metals are presented in Table 125 and summarized in Figure 5-31. Arsenic was detected at a level in excess of its MCL of 10 ug/L in the initial sample from monitoring well BDS-2 at a concentration of 55.2 ug/L. Arsenic was detected in the confirmatory sample and duplicate from well BDS-2 at concentrations of 35.6 and 35 ug/L, respectively. Arsenic was also detected in the April 2003 supplemental sample collected at BDS-2 in excess of its MCL at well BDS-2 at levels of 34 ug/L (total) and 26.3 ug/L (dissolved). The laboratory also identified barium, cadmium, chromium, cobalt, nickel and/or vanadium at wells BDS-1 and BDS-2, but at concentrations less than groundwater screening levels.

Free Product Observations

Table 5-127 presents a summary of available FPH thickness measurements taken at monitoring wells at the Barge Dock Sump from July 1996 to April 2006. During the initial field investigation in July 1996 through January 1997, FPH was observed in newly-installed

monitoring wells BDS-2 and BDS-3 and in existing well MW-9. Maximum reported apparent FPH thicknesses were 0.02 ft at BDS-2, 0.49 ft at BDS-3, and 0.13 ft at MW-9 as measured between July 1996 and January 1997. An FPH sheen was also observed at wells BDS-5 and BDS-6.

The most recent FPH measurements from April 2006 show measurable FPH at well BDS-3 with a thickness of 1.19 ft. A sheen was observed at well BDS-2. FPH is not observed at any of the other monitoring wells.

Figures 5-32A, 5-32B, and 5-32C, graphically present quarterly FPH measurement data at the Barge Dock Sump for 1997, 2001, and 2005, respectively. The locations of the monitoring wells are also shown in the figures. The FPH plume is generally stable. The measurements show that the extent of FPH has been defined at this SWMU and is limited to the immediate vicinity of the unit.

Product baildown tests were conducted at wells BDS-3 and MW-9 to estimate the formation product thickness. The results, which are presented in Appendix I, showed estimated thicknesses for wells BDS-3 and MW-9 of 0.07 and 0.01 ft, respectively. Characterization of the free product at well BDS-3 by chemical fingerprinting showed a signature indicative of a severely degraded topped fraction of a crude oil possibly with a subordinate kerosene contribution. The specific gravity of the product was determined to be 0.84. The free product characterization results are presented in Appendix I.

5.17.4 Conclusions

Detailed chemical analysis of soil samples at the Barge Dock Sump did not detect VOCs or BNAs in the surface and subsurface zones in excess of RBSLs. Arsenic was detected in soil at five locations at concentrations in excess of its direct contact RBSL. However, the concentrations were below background levels of arsenic. A number of other metals were detected in the surface and subsurface zones, but all at concentrations below RBSLs.

Detailed chemical analysis of the groundwater sample collected at the Barge Dock Sump did not confirm the presence of VOCs or BNAs in groundwater at concentrations in excess of groundwater screening levels.

A localized area of impacted groundwater was identified at BDS-2 with total and dissolved arsenic concentrations in excess of its MCL of 10 ug/L. August 1996 RFI sample results from downgradient well BDS-1 (dissolved arsenic concentration of 9.9 BJ ug/L) demonstrate that the area of impact has been delineated. The area of impact is shown in Figure 5-31. Since the impacted groundwater has been fully delineated, no impact to local surface water or sediment is expected. No other metals were detected in groundwater at levels in excess of screening levels.

A localized FPH plume was detected on the water table at the Barge Dock Sump during implementation of the RFI in 1996 and 1997. The FPH plume has been fully delineated. FPH is routinely monitored and recovered as part of a site-wide interim corrective measure being implemented at the SCYI facility. Historical product thickness measurements indicate that the FPH plume is not migrating and is therefore stable. Groundwater sampling results demonstrate that groundwater at the Barge Dock Sump has not been impacted by dissolution of the FPH.

No further investigation of soil or groundwater quality is warranted at the Barge Dock Sump. However, measurement and recovery of FPH will continue at the unit as part of interim measure activities.

Groundwater sampling for total and dissolved arsenic will be performed at wells BDS-1 and BDS-2 on a semiannual basis, however. The work will be performed as per the facility's RCRA permit requirements.

5.18 Data Quality

All field sample collection activities and laboratory analyses of samples were performed in conformance with the provision of the EPA-approved Field Sampling Plan and Quality Assurance Project Plan included in Appendix A and B of the RFI Work Plan. Data validation was performed on all soil and groundwater sample results utilizing EPA Region 2 Functional Guidelines. The data validation work was performed by Dataval Inc., of Endwell, New York, Premiere Environmental Inc., of Merrick, New York, or Rafael Infante, a certified chemist in Puerto Rico. The full data validation reports are provided in PDF format on a CD-ROM in Appendix J of this report. All data quality objectives established in the QAPP have been achieved.

Data were either unqualified or qualified as estimated (J-qualifier). Details of any qualifications are provided in the data validation reports. Groundwater results for 3,3'-dichlorobenzidine from wells MDS-4, 40-11, and 40-12 from Sample Data Group (SDG) N40627C were rejected during data validation. Since this compound is not a constituent of concern, the data rejection does not affect the conclusions of the report. Groundwater results for arsenic and selenium in the duplicate sample at well 40-21 from SDG N91847CA (Table 5-52) were rejected since dissolved results were greater than total results by a percentage exceeding quality control criteria. Since the primary sample results for arsenic and selenium at well 40-21 were useable, the rejections do not affect the conclusions of the report. All other data were useable.

5.18.1 Tentatively Identified Compounds and Elevated Sample Quantitation Limits

Tentatively identified compounds (TICs) and elevated sample quantitation limits (SQLs) in soil are discussed in this section. TICs occur for VOC and BNA analysis, but not for metals. The source of the TICs in soil is attributed to petroleum contamination. In certain cases, the presence of high TIC levels or other interferences causes elevated SQLs. The occurrence of elevated SQLs for soil in excess of RBSLs is also discussed. There were no occurrences in groundwater of interferences that caused elevated SQLs in excess of groundwater screening levels.

It should be noted that the identification of TICs by the laboratory is not always reliable, since TICs are identified using library mass spectra, rather than with specific calibration compounds. Additionally, the concentrations of TIC determined by the laboratory are not reliable since the analyses are performed without the use of calibration solutions for the various compounds.

Total TIC levels exceeded 100 mg/kg at the Barge Dock Sump (SWMU 34) from a sample depth of 7.5-8 ft bgl at borings 34-04, 34-05, and 34-06. The borings are located in the central part of the unit. Combined total VOC and BNA TIC levels at borings 34-04, 34-05, and 34-06 ranged from 979 to 2,617 mg/kg. Free-phase hydrocarbon and/or staining were also observed at the same depth in these borings, which is the source of the elevated TIC levels. The VOC and BNA TICs were generally identified as unknowns, unknown alkanes, cyclo-alkanes, methylated cyclo-alkanes, propyl and methylated benzene, and a naphthalene compound.

Total TIC levels exceeded 100 mg/kg at SWMU 40 at boring 40-07 at a depth of 12.5-13 ft bgl and at boring 40-10 from a depth of 5.5-6 ft bgl. Combined total VOC and BNA TIC levels at borings 40-07 and 40-10 were 265 mg/kg and 382 mg/kg, respectively. Free-phase hydrocarbon and/or staining were also observed at the same depth in these borings, which is the source of the elevated TIC levels. The VOC and BNA TICs were generally identified as unknowns, unknown alkanes, cyclo-alkanes, and a methylated benzene. Additionally, elevated BNA SQLs occurred at boring 40-03 at a depth of 3-3.5 ft bgl.

Total VOC TIC levels above 100 mg/kg occurred at SWMUs 3 and 39, however, SQLs were not affected. Therefore, there was no impact on comparison of analytical results to soil screening levels.

The BNA SQLs for the samples with TIC levels above 100 mg/kg at SWMUs 3, 34, 39, 40 and 45 were generally elevated by a factors varying from about two to ten. None of the elevated SQLs were above soil screening levels for likely constituents of potential concern at the individual SWMUs, however, with the exception of benzo(a)pyrene. The SQLs for this compound were above the direct contact RBSL by factors varying from about 2 to 21 (that is, by a factor of 5 at SWMU 3, by a factor of 10 at SWMU 34, by a factor of 2 at SWMU 39, by a factor of 21 at SWMU 40, and by a factor of 11 at SWMU 45). Also, only for the sample at

boring 40-03 (3-3.5 ft depth), the SQLs for benzo(a)anthracene and benzo(b)fluoranthene were above respective RBSLs by a factor of about two.

VOC SQLs for the two samples with TIC levels above 100 mg/kg at SWMU 45 were elevated by a factor of about 120. Benzene was the only likely constituent of potential concern for which the SQL was greater than the soil screening level (migration to groundwater). However, benzene was not detected in the groundwater sample at location 45-09, which indicates that either benzene was not present in the soil or it was not present at concentrations that could affect the groundwater quality. This is also the likely situation at location 45-05. Hence, even though the SQL for benzene was above the migration to groundwater soil screening level, no impact is indicated.

The VOC SQLs for the three samples with TIC levels above 100 mg/kg at SWMU 34 were elevated by factors ranging from about 130 to 720. Benzene was the only likely constituent of potential concern for which the SQL was greater than the soil screening level (migration to groundwater). Groundwater sampling results from this unit, as discussed in Section 5-17, do not confirm any benzene impact to groundwater, however. Hence, even though the SQL for benzene was above the migration to groundwater soil screening level, no impact is indicated.

The VOC SQLs for the two samples with TIC levels above 100 mg/kg at SWMU 40 were elevated by factors of 10 and 120. Also, the VOC SQLs for the single sample at adjacent SWMUs 39 were elevated by a factor of about five. Benzene was the only likely constituent of potential concern for which the SQL was greater than the soil screening level (migration to groundwater). However, benzene was not detected in the groundwater samples at any of the ten locations sampled during the RFI, as discussed in Section 5.9. This indicates that either benzene was not present in the soil or it was not present at concentrations that could affect the groundwater quality.

The TICs identified in the various soil samples discussed above do not have any known toxicities. Additionally, there are no compounds similar to the TICs that can be used as a surrogate for toxicities. Therefore, the presence of the TICs does not indicate a demonstrated impact to human health.

5.18.2 Field Procedures

The QAPP QA/QC policy requires that specific sampling procedures be followed to minimize contamination of samples and ensure that samples are representative of the area being tested. Sampling procedures outlined in the RFI Work Plan and the QAPP were followed.

Trip blanks were prepared and analyzed to determine if any systematic volatile constituent contamination occurred during sample transport, glassware cleaning and laboratory storage. Equipment blanks were collected to verify that the sampling equipment did not cross-contaminate samples and that decontamination procedures were sufficient.

The QAPP policy requires that sample custody be documented. At the time of collection, the samples were identified, logged, placed in a container and tagged. The samples were identified by a unique sample number that identified the project name, sample type and number. The sample was then logged into the field notebook. After the sample was tagged and logged, the sample analysis form was filled out for the sample. Finally, the sample was packed for shipping, the chain-of-custody (COC) form completed and the sample sent to the designated laboratory (Core Laboratories, Inc., Edison, New Jersey, and Accutest Laboratory, Inc., of Dayton, New Jersey) where final custody of the samples was accepted. All sample documentation and COC forms were completed. COC forms are included with the raw sample data reports from the laboratory, which will be submitted to EPA under separate cover upon request.

5.18.3 Laboratory Procedures

The QAPP policy requires that COC forms be signed by the field sampling representative and laboratory sample custodian. All soil samples collected for the PRSOC RFI were sent with COC forms documenting the sample collector's name, signature, mailing address and telephone number, a unique identification number, the types of analyses required for each sample and the dates of sample collection, shipment and receipt by the laboratory.

Sample holding times were determined by comparing the sample receipt times noted on the COC and the date of analysis included with the resulting laboratory data. The recommended sample

holding times for the RFI analytical methods are presented in the QAPP. Where holding times were exceeded in a few cases when date of collection was considered, the data were qualified during data validation by AMAI as estimated values. The holding times and resulting qualifiers for all samples are presented in the individual sample delivery group (SDG) data validation reports.

Sample cooler temperatures were recorded upon arrival at the laboratory. The recommended temperatures for the RFI analytical methods are presented in the QAPP. Where cooler temperatures were above the recommended in a few cases, the data were qualified during data validation by AMAI as estimated values. The temperatures and resulting qualifiers for all samples are presented in the individual SDG data validation reports.

Laboratory method blanks were analyzed for BNAs, VOCs, BTEX, and/or MSL metals. Based on the results of data validation, a number of VOCs and BNAs were considered laboratory contaminants. These include acetone, methylene chloride, 2-butanone, and the general group of BNA phthalates. Where these compounds were considered laboratory artifacts, the data were qualified by AMAI as estimated values. The results of all the method blanks are included in the data validation reports. Nevertheless, suspected laboratory contaminants were compared to soil and/or groundwater screening levels.

Matrix spikes (MS) and matrix spike duplicates (MSD) were analyzed by the laboratory for all data sets. For each MS/MSD data set, the relative percent difference (RPD) is calculated and control limits are given. The results of the laboratory matrix spike/matrix spike duplicates are presented in the data validation reports, which are provided in PDF format on a CD-ROM in Appendix J of this report.

5.18.4 Data Quality Summary

Field completeness involves an assessment of the number of samples planned to be collected and the number actually collected. The field completeness goal of 100 per cent designated in the RFI Work Plan for detailed chemical analysis of soil samples above the water table was achieved, with the exception that at the Watery Oil Separator (SWMU 43), BNAs and metals were not

collected at one of four soil sampling locations. The sampling results did not indicate that the change in sampling affected the overall contamination assessment, as discussed in Section 5.12.4. At eight of the SWMUs investigated additional delineation samples were collected and the number of soil samples exceeded the number proposed in the Work Plan.

The completeness goal of 100 per cent as proposed in the Work Plan was achieved for groundwater sampling at wells without free product. As per groundwater sampling protocols, groundwater samples were generally not collected at wells with free product. At five SWMUs additional delineation samples were collected and the number of groundwater samples exceeded the number proposed in the Work Plan.

Achievement of the laboratory completeness goal depends on the number of samples that are of sufficient quality to fulfill the data objectives. Instrument calibrations for all data sets were within QC limits for the majority of the analysis. There were minor infractions of QA/QC procedures. These include, and seem to be limited to: occasional, out of range surrogate recoveries on soil samples, and very limited out of range MS/MSD recoveries. Higher detection limits for some samples analyzed were necessary because of elevated sample concentrations. Where these excursions were noted, the data was qualified accordingly as presented in the data validation reports. Sample analyses resulted in data with quality that has not been impacted to the point of compromising data quality objectives outlined in the QAPP and, therefore, the laboratory completeness goal was attained.

To address the comparability objective of the RFI, standard field sampling techniques and analytical methods were used throughout the soil sampling event. Since the sampling techniques and analytical methods outlined in the RFI Work Plan and the QAPP were followed, the data are comparable.

Field representativeness was addressed as part of the RFI Work Plan. Laboratory representativeness has been assured by the collection of field blanks and duplicates and the analysis of laboratory method blanks and MS/MSD samples as well as surrogate recoveries during analyses.

Based on the results of data validation, the data collected in accordance with the RFI Work Plan is of sufficient quality and quantity to describe the nature and extent of soil contamination at the SCYI refinery at the SWMUs investigated.

6.0 Contaminant Fate and Transport

An evaluation of contaminant fate and transport is discussed in this section. The results of the SWMU-specific investigations presented in Section 5 are used along with fate and transport characteristics to assess the expected future chemical distributions in the subsurface. The evaluation will provide the basis for the development of any remedial strategies.

The mechanisms that influence the fate and transport of organic and inorganic chemicals in the subsurface include both physical and chemical characteristics. A qualitative and descriptive discussion is presented below to provide an understanding of the most important factors that influence fate and transport of contaminants at the SCYI facility.

The contaminant characteristics and potential transport mechanisms for the organic and inorganic constituents identified in excess of soil RBSLs and/or groundwater screening levels during the RFI are discussed below.

6.1 Organic Constituents

The organic constituents found in surface and subsurface soil at the SCYI facility in excess of RBSLs included both volatile organic compounds (VOCs) and base-neutral acid extractable compounds (BNAs). For VOCs in soil, only methylene chloride exceeded an RBSL (migration to groundwater). Methylene chloride is a common laboratory contaminant, however. BNAs that exceeded RBSLs in soil consisted benzo(a)pyrene and 2-methylnaphthalene. VOCs and BNAs that exceeded ecological screening levels in surface soil consisted of acetone, di-n-butyl phthalate, and naphthalene. Acetone and phthalates are common laboratory contaminants, however. Benzene, 2-methylnaphthalene, and naphthalene exceeded groundwater screening levels. Details of the detections and screening level exceedances for the human health and ecological evaluation are presented in Sections 5 and 7, respectively.

The fate and transport of organic compounds in both saturated and unsaturated environments at the SCYI site are influenced by the following processes:

- Adsorption/desorption - The flow of organic compounds through an aquifer will be retarded with respect to the average groundwater flow velocity due to adsorption of the

constituents to the aquifer material. The degree of retardation is in direct relationship to the soil bulk density, moisture content, organic carbon adsorption coefficient (K_{oc}), and fraction available organic carbon. The movement of organic compounds through the vadose zone will be similarly affected, although the movement mechanism is more complex than through the saturated zone.

- Advection - The physical processes of contaminant transport (as a solute) at the average linear velocity of groundwater in the direction of flow.
- Diffusion - The chemical processes that result in the movement of contaminants in response to concentration gradients.
- Dispersion - Spreading and mixing of chemical constituents in groundwater caused by diffusion and mixing due to microscopic variations within and between pores.
- Solubility - Aqueous solubility refers to the maximum concentration of a chemical that can be dissolved in pure water at a reference temperature.
- Biotransformation - Chemical alteration and degradation of organic compounds brought about by microorganisms.
- Volatilization - The transfer of contaminants as a vapor from the liquid phase into either the soil gas in the unsaturated zone or the atmosphere.

The behavior of organic compounds can be estimated using environmental fate parameters which relate to the physical and chemical properties of the individual contaminants in the environment. The following chemical and physical parameters have been identified as important factors controlling organic compound mobility and persistence in the subsurface at the SCYI refinery:

- molecular weight
- density
- Henry's Law constant
- vapor pressure
- adsorption coefficients
- solubility

- viscosity
- bioconcentration factor

A list showing selected physical and chemical parameters for organic constituents that were detected above screening levels is presented in Table 6-1.

Organic contaminants that exceeded screening levels in RFI surface and subsurface soil samples and groundwater samples at the SCYI facility consisted of certain VOCs and BNAs, as discussed above. In general, the mobility of compounds from these groups tends to be retarded in response to the physical and chemical mechanisms described above. This indicates that the contaminants will be retained by the soil and not migrate. Because of soil adsorption, VOC and BNA transport in groundwater would be retarded with respect to the average groundwater flow velocity. Other attenuation factors, such as biodegradation and dispersion would reduce downgradient concentrations in groundwater.

6.2 Inorganic Constituents

The only inorganic constituents that exceeded RBSLs for surface and subsurface soil were arsenic, chromium, nickel, and selenium. As discussed in Section 7.3, cadmium, cobalt, chromium, lead, nickel, and vanadium exceeded ecological screening levels in surface soil. (Background levels of cadmium, chromium, cobalt, lead, and vanadium also exceed ecological screening levels). The only inorganic constituent detected in groundwater above its screening level was arsenic. Details of the detections and screening level exceedances for the human health and ecological evaluation are presented in Sections 5 and 7, respectively.

Compound-specific fate and transport parameters are generally not applicable to inorganic contaminants. The fate of inorganic contaminants is primarily dependent on the solubility of the individual constituent which is determined by the pH, oxidation-reduction potential, and temperature of the environment. The chemical and physical characteristics and reactions that can potentially govern the fate and transport of the inorganic contaminants are solubility/precipitation, adsorption/desorption, ion exchange, and oxidation-reduction reactions. These reactions and processes are interrelated which greatly complicates the fate and transport of inorganic species in the subsurface and are presented as follows:

- Solubility/precipitation - Concentrations of inorganic contaminants can be estimated based on equilibrium chemistry. If a contaminant's concentration in the aqueous phase exceeds its solubility limit, the contaminant will precipitate to form a solid phase. A change in oxidation-reduction conditions and/or pH of an aquifer can affect the solubility of contaminants.
- Adsorption/desorption - Surface adsorption/desorption can play an important role in the fate and transport of inorganics, particularly for positively charged metal ions. Adsorption and desorption to and from surfaces is generally considered to be a two-dimensional mechanism which is dependent on the surface charge, the particular ion and its charge, and the pH of the water. Although estimation of these processes as a mechanism of contaminant transport is often site-specific, positively charged metal ions, such as arsenic generally tend to be adsorbed, and its transport will probably be at a slower rate than groundwater flow velocity.
- Ion exchange - Ion exchange is similar to adsorption but occurs in a three-dimensional porous matrix where ions are held by electrostatic rather than coordination bonding. Ion exchange is an important process affecting fate and transport of the alkali metals, e.g., sodium and potassium, and the alkaline earth metals, e.g., calcium and magnesium. Ion exchange may influence the fate and transport of trace metals if they are present in sufficient concentrations to compete with the more concentrated alkali and alkaline earth metals.
- Oxidation-reduction - Oxidation-reduction reactions involve changes in the oxidation state of elements. Oxidation-reduction levels in groundwater are determined by rates of introduction of oxygen by groundwater circulation and by the consumption of oxygen by bacterially mediated decomposition of organic matter. The oxidation-reduction potential of groundwater is affected by the presence of oxidation-reduction buffers, such as iron and manganese oxides and hydroxides.

A list showing selected physical and chemical parameters for inorganic constituents that were detected above screening levels is presented in Table 6-1.

The inorganic compounds detected at the SCYI refinery include the group of MSL metals which tend to be retarded in their mobility in the subsurface in response to the mechanisms as described

above. In addition, where detected, they were most often found at concentrations below soil and groundwater screening levels. Most of these metals were also found in background soil samples and, therefore, may not be attributed to refinery operations. Based on soil water partition coefficients, the order of retardation of the metals detected above screening levels from greatest to least is as follows: selenium, nickel, and arsenic.

6.3 Residual Petroleum Product

Free product on the water table has been observed at the following five SWMUs and/or areas as follows: the Northeast Refinery Area, the East API Separator (SWMU 3), the Watery Oil Separator (SWMU 43), the Main Dock Sump (SWMU 33), and the Barge Dock Sump (SWMU 34). Residual product was also observed in the soil at the East Aisle Ditch (SWMU 45). Chemical fingerprinting data of the free product generally indicates an old product with significant degradation. No chemical fingerprint data was available for the East API Separator, although visual inspection indicated it to be a sticky, viscous weathered oily product. Also, no chemical fingerprint data was available for the residual product in soil at the East Aisle Ditch (SWMU 45). Since the free product is generally limited to the area of the SWMUs and no migration has been observed since commencement of monitoring in 1997, the product plumes are stable. Groundwater sampling results from the SWMUs also suggest that the dissolved product plumes, where detected, are limited in extent and are stable.

The fate and transport of petroleum product released to the subsurface is dependent on many of the mechanisms discussed above for the organic compounds. These include volatilization, adsorption, immiscible fluid flow, dispersion and biodegradation. The physical characteristics of the release and the hydrogeology of the site are also controlling factors. These include the rate and amount of the release, composition and specific gravity of the product, variations in soil permeabilities, moisture content, and depth to groundwater.

Where the petroleum release consists of light non-aqueous phase liquids (LNAPL), such as at the SCYI facility, the release migrates vertically under gravitational forces until it reaches the top of the saturated zone where it will form a lense of ponded product on the surface of the water table. If the subsurface geology is relatively isotropic and permeable, the product will tend to move in the general direction of groundwater flow. Product flow contrary to this model occurs where permeability contrasts are encountered and the product tends to move along conduits of relatively higher permeabilities, at times against the local groundwater gradients; this situation is

interpreted to not occur at the SCYI facility. Based on changes (or lack of changes) over time a product plume and associated dissolved product plume can be characterized as shrinking, stable, or expanding. Accordingly, the product plumes at the SCYI facility are interpreted to be stable or shrinking.

Where the petroleum release consists of dense non-aqueous phase liquids (DNAPL), the release migrates vertically under gravitational forces like LNAPLs, but instead continue to migrate downward below the water table because of the higher specific gravity of the product. The release will continue to migrate downward as a density flow until it is adsorbed and retained by the soil or it encounters a large contrast in the permeability of the geologic formations such as at a clay layer. DNAPLs were not encountered at the SCYI facility, however.

7.0 Exposure Assessment

This section presents an exposure assessment, which includes an evaluation of potentially exposed human populations and environmental systems that are susceptible to contaminant exposure at SWMUs at the SCYI facility.

7.1 Potentially Exposed Human Populations

Human populations and land use in the vicinity of the SCYI facility area are described in this section. Further details, including pertinent maps of the area and census data, are presented in the Description of Current Conditions Report (AMAI, 1994).

7.1.1 Demography

Approximately 36,483 people live within the municipality of Yabucoa according to 1990 census data. The highest population density is within the town area of Yabucoa where about 7,262 people reside. Yabucoa is about 1.5 miles west of the facility. The median age of residents of the municipality is 26 years old. About 8 percent of the population is under 5 years old. Camino Nuevo and Juan Martin barrios, which contain the residential communities located closest to the SCYI facility, have populations of 3,530 and 3,230, respectively. The most densely populated section of Camino Nuevo barrio is located about 2,500 ft to the southeast of the facility; the most densely populated area of Juan Martin barrio is located about 6,000 ft to the southwest.

Approximately 350 employees work at the SCYI facility although the work force is presently being reduced due to company restructuring. The worker population in other industries and commercial establishments in the Yabucoa area is unknown. An unspecified number of people shop at retail facilities associated with these establishments.

7.1.2 Land Use

The SCYI facility is surrounded primarily by agricultural lands. These lands are used mainly for producing sugar cane and plantains with several pasture and grazing areas. The Caribbean Sea is located at the eastern border of the facility.

The nearest residential community is located about 2,500 ft to the southeast of the facility. Population density in this community is low. The residential area with the greatest population density is the town of Yabucoa located about 1.5 miles to the west of the facility.

The only recreational facility in the immediate vicinity of the facility is one provided by SCYI for its employees. It consists of a baseball park, basketball courts, two tennis courts, and a club house. They are limited to use by SCYI employees and their relatives.

Lucia Beach, which is used by local residents for recreational purposes and is bordered by a coconut grove, is a stretch of beach about 4300 ft long along the southern portion of Yabucoa Bay of the Caribbean Sea. At its nearest point, Lucia Beach is located about 2400 ft east of the Tank Farm Area and about 2100 ft south of the Dock Area.

A light manufacturing facility is located about 300 feet east of the eastern main entrance to the Refinery Area. It is reportedly owned by New Generation, Inc., whose manufacturing includes a locally branded decreasing agent.

No historical or archeological sites exist within 1000 feet of any of the SWMUs.

7.2 Potential Migration Pathways and Human Receptors

The potential for migration of contamination at the SCYI facility via soil, groundwater, surface water, and air pathways is evaluated in this section. For human and environmental exposure to contamination to occur, the following four components must be present: (1) the existence of a contamination source, (2) a transport pathway, (3) an exposure pathway, and (4) the presence of human or environmental receptors. If any one of these components is lacking, the overall exposure pathway is incomplete and risk to human health and the environment is not indicated.

7.2.1 Soil Pathway

The potential impact to human health from exposure to soil contamination is evaluated in this section. Soil transport mechanisms, human exposure pathways, and receptors are identified in the evaluation.

Sources of Contamination

Prior drippage or accidental spillage of oil and petroleum products to the soil are the primary sources of historical soil contamination at the SCYI facility.

The maximum detected concentrations of constituents in surface soil and subsurface soil at the various SWMUs are presented in Tables 7-1 and 7-2, respectively. Table 7-3 summarizes the constituents that exceeded RBSLs at the various SWMUs.

For surface soil, direct-contact RBSLs for VOCs, BNAs, and MSL metals were not exceeded at any of the SWMUs, with the exception of benzo(a)pyrene and arsenic. Benzo(a)pyrene (230 J ug/kg) exceeded its direct-contact RBSL of 210 ug/kg in surface soil at the East API Separator (SWMU 3) at one location. The benzo(a)pyrene detection did not exceed the outdoor inhalation RBSL of 2.6E+06 ug/kg, however. Arsenic exceeded its direct-contact RBSL of 1.6 mg/kg in surface soil at the following seven SWMUs: West API Separator (SWMU 2), East API Separator (SWMU 3), Barge Dock Sump (SWMU 34), Slop Oil Tank (SWMU 35), Northeast Refinery Area (SWMU 40), Watery Oil Separator (SWMU 43), and the East Aisle Ditch (SWMU 45). The arsenic levels at these SWMUs ranged from 1.8 B to 7.3 mg/kg, which were below the background level of 8.7 mg/kg.

For surface soil, RBSLs for inhalation of volatile/particulates in outdoor air were not exceeded at any SWMU, including benzo(a)pyrene at SWMU 3. Chromium (38.2 mg/kg) exceeded its migration to groundwater RBSL of 38 mg/kg at SWMU 40 at one location. Nickel (153 and 233 mg/kg) exceeded its migration to groundwater RBSL of 130 mg/kg at two locations.

For subsurface soil, direct-contact RBSLs for VOCs, BNAs, and MSL metals were not exceeded at any of the SWMUs, with the exception of benzo(a)pyrene and arsenic. Benzo(a)pyrene exceeded its direct-contact RBSL of 210 ug/kg in subsurface soil at one location (400 J ug/kg) at the Dissolved Air Flotation Unit (SWMU 36), at one location (2600 J ug/kg) at the Northeast Refinery Area (SWMU 40), and at one location (1000 J ug/kg) at the East API Separator (SWMU 3). Arsenic exceeded its direct-contact RBSL of 1.6 mg/kg in subsurface soil at the following nine SWMUs: West API Separator (SWMU 2), East API Separator (SWMU 3), Barge Dock Sump (SWMU 34), Dissolved Air Flotation (DAF) Unit (SWMU 36), Hazardous Waste Mixing Box (SWMU 39), Northeast Refinery Area (SWMU 40), Watery Oil Separator (SWMU 43), Ballast Basin Skimmer Area (SWMU 44), and the East Aisle Ditch (SWMU 45). With the

exception of one location at the Watery Oil Separator (SWMU 43), the arsenic levels at these SWMUs ranged from 1.7 BJ to 6.1 J mg/kg, which were below the background level of 8.7 mg/kg. At the one location at the Watery Oil Separator (SWMU 43), the arsenic level was 11 mg/kg at a depth of 7-7.5 ft, which only slightly exceeded the background level.

For subsurface soil, methylene chloride exceeded its migration to groundwater soil RBSL of 20 ug/kg at one location each at the East API Separator (SWMU 3) and Watery Oil Separator (SWMU 43). The concentrations were 48 J ug/kg and 23 J ug/kg, respectively. Methylene chloride is a common laboratory contaminant, and its detection in soil is likely related to a laboratory artifact. Additionally, methylene chloride was not detected at the downgradient groundwater monitoring wells at the Watery Oil Separator (WOS-4A and WOS-5A). Also, at the East API Separator, since the methylene chloride concentration does not significantly exceed its migration to groundwater RBSL, and since this constituent has not been detected at any of the wells at the unit or at downgradient wells [wells 45-01 and 45-02 of the East Aisle Ditch (SWMU 45) and wells at the Barge Dock Sump (SWMU 34)], this constituent in soil has had no significant impact on groundwater.

For subsurface soil, 2-methylnaphthalene exceeded its migration to groundwater RBSL of 17,000 ug/kg at three locations (concentrations ranging from 31,000 D to 110,000 D ug/kg) at the Barge Dock Sump (SWMU 34), but was not detected in the groundwater above its screening level.

For subsurface soil, migration to groundwater RBSLs were exceeded for nickel and selenium at the Northeast Refinery Area (SWMU 40). Nickel (141 mg/kg) exceeded its migration to groundwater RBSL of 130 mg/kg at one location. Selenium (7.6 J mg/kg) exceeded its migration to groundwater RBSL of 5 mg/kg at the same one location. The exceedances were not significant. Also, nickel and selenium were not detected in groundwater above screening levels at the Northeast Refinery Area, however.

Transport Pathway

A potential soil transport pathway at the SCYI facility is from leaching of contamination through soil to groundwater. However, at locations described above where the soil quality exceeded migration to groundwater RBSLs, no detections occurred in groundwater above screening levels. This indicates that the migration to groundwater pathway is incomplete.

Due to the limited areas at which benzo(a)pyrene and arsenic exceeded surface soil RBSLs, soil transport via surface runoff, deposition from fugitive dust, and vehicle tracking are considered to be unlikely transport pathways. Additionally, the design of the stormwater collection system at the SCYI facility inhibits soil migration from the facility. Uptake from contaminated soil by agricultural crops is an incomplete pathway because there is no agriculture at the facility.

Exposure Pathways

Potential human exposure pathways to soil contamination are from soil ingestion and/or dermal contact.

Receptors

Exposure to surface soil may occur to on-site workers and construction workers. Exposure to subsurface soil may occur to construction workers.

Soil Exposure Evaluation

The direct-contact RBSL for benzo(a)pyrene of 210 ug/kg was slightly exceeded in surface soil at the East API Separator (SWMU 3). The exceedance occurred at in a limited area at one location at a level of 230 J ug/kg. Exposure to surface soil may occur for on-site and construction workers.

The direct-contact RBSL for arsenic of 1.6 mg/kg was exceeded in surface soil at seven SWMUs, as discussed above. Exposure to surface soil may occur for on-site and construction workers. None of the arsenic levels exceeded the background level of 8.7 mg/kg, however.

The direct-contact RBSL for benzo(a)pyrene of 210 ug/kg was exceeded in subsurface soil at the Dissolved Air Flotation Unit (SWMU 36) (400 J ug/kg), the Northeast Refinery Area (SWMU 40) (2,600 J ug/kg), and East API Separator (SWMU 3) (1,000 J ug/kg). Exposure to subsurface soil may occur for construction workers.

The direct-contact RBSL for arsenic of 1.6 mg/kg was exceeded in subsurface soil for arsenic at nine SWMUs, as discussed above. Exposure to subsurface soil may occur for construction workers. With the exception of one location at the Watery Oil Separator (SWMU 43), none of

the arsenic levels exceeded the background level of 8.7 mg/kg, however. At the one location at the Watery Oil Separator (SWMU 43) the arsenic level was 11 mg/kg, which only slightly exceeded the background level.

The migration from soil to groundwater pathway appears to be incomplete. At locations where the soil quality exceeded migration to groundwater RBSLs, no detections occurred in groundwater above screening levels at the units or at downgradient wells. Hence, there is no evidence of any significant impact.

SCYI has implemented good housekeeping procedures that have minimized the potential for soil contamination.

7.2.2 Groundwater Pathway

The potential impact to human health from exposure to groundwater contamination is evaluated in this section. Groundwater transport mechanisms, human exposure pathways, and receptors are identified in the evaluation.

Sources of Contamination

The sources of contamination that could potentially impact groundwater resources in the SCYI area are from dissolution of contaminants from areas where free product was observed on the water table, and from past releases of petroleum products containing hazardous constituents that may leach through the soil to the groundwater. As discussed above, significant sources of soil contamination were not found and the migration from soil to groundwater pathway appears to be incomplete.

The maximum detected concentrations of constituents in groundwater at the various SWMUs are presented in Table 7-4. Table 7-5 summarizes the constituents in groundwater that exceeded screening levels at the various SWMUs.

Detections in groundwater above screening levels occurred at four SWMUs. Arsenic (12.3 J ug/L) was detected above its screening level of 10 ug/L at well AB-1 of the North Aeration Basin (SWMU 17). At well 40-21 of the Northeast Refinery Area (SWMU 40), 2-methylnaphthalene (36.9 ug/L) was detected above its screening level of 24 ug/L. At well MDS-4 of the Main Dock

Sump (SWMU 33), benzene (60 ug/L), naphthalene (21.9 ug/L), and 2-methylnaphthalene (60.1 ug/L) were detected above respective screening levels of 5 ug/L, 6.2 ug/L, and 24 ug/L. At well BDS-2 of the Barge Dock Sump (SWMU 34), arsenic (34 ug/L) was detected above its screening level of 10 ug/L. No water supply wells are located downgradient of these areas. Consequently, there are no drinking water receptors.

FPH on the water table has been observed at the following five SWMUs and/or areas: the Northeast Refinery Area (SWMU 40), the East API Separator (SWMU 3), the Watery Oil Separator (SWMU 43), the Main Dock Sump (SWMU 33), and the Barge Dock Sump (SWMU 34). Residual product was also observed in the soil at the East Aisle Ditch (SWMU 45).

Transport Pathway

At SWMUs with FPH on the water table, dissolution of contamination to groundwater with downgradient transport is the main transport pathway.

The clayey nature of the soil above the water table at the Refinery Area suggests that it has a high capacity to absorb contaminants prior to reaching the water table. The low permeability surficial clay also minimizes infiltration to the groundwater. If a contaminant were to reach the groundwater, its movement would be significantly retarded because of the low permeability of the water-bearing units. Other factors such as dispersion, biodegradation, volatilization, and oxidation in the groundwater environment also have considerable effect in retarding or mitigating contaminant migration. In the Tank Farm and Dock Areas, the surface soil is sandier and more permeable, with less attenuation.

As illustrated in the groundwater elevation and flow direction map for the facility (Figures 2-17 and 2-18) the general flow at the Refinery Area direction is to the northeast; at the Tank Farm Area the flow direction is generally to the east; and in the Dock Area the flow direction is generally to the east and southeast. The direction of contaminant transport is controlled by the groundwater flow direction. As discussed in Sections 2.8 and 2.9, pumping from the well field in the central part of Yabucoa Valley does not appear to have affected the groundwater flow direction at the facility. Also, changes in water level due to tidal effects at the Dock area do not appear to change the overall groundwater flow direction as described above.

Average horizontal groundwater velocities were calculated to be about 0.01 ft/day in the Refinery Area, 0.07 ft/day in the Tank Farm area, and 0.8 ft/day in the Dock Area (reference Section 2.9). The large range in velocities is mainly due to the large range in hydraulic conductivities as the water-bearing zone in the Refinery Area is clayey compared to the sandy water-bearing zone in the Dock Area. Contaminant transport rates are usually retarded compared to average groundwater flow velocities.

As discussed in Section 4.3, the vertical hydraulic gradient at the Northeast Refinery Area varies seasonally between upward and downward. In the Tank Farm Area, the vertical gradient is downward at the East API Separator (SWMU 3); at the Watery Oil Separator (SWMU 43) the gradient varies seasonally between upward and downward. In the Tank Farm and Refinery Areas it is likely that the vertical flow direction within the uppermost aquifer zone is upward such that groundwater discharges to the Caribbean Sea. No contamination above screening levels was detected in the deep groundwater at nested wells in the Northeast Refinery Area (SWMU 40), East API Separator (SWMU 3), and Watery Oil Separator (SWMU 43).

Potential groundwater transport by groundwater discharge to nearby surface water is discussed below for the surface water assessment.

Exposure Pathways

Human exposure pathways considered are ingestion and dermal contact with contaminated groundwater from public or industrial water supplies.

Receptors

Groundwater receptors include people in the area who may use groundwater from public or industrial supply wells for drinking or bathing. The main aquifer for water production is located in the central part of Yabucoa valley where the highest aquifer transmissivities are found. The town of Yabucoa uses 0.57 million gallons per day of water derived mostly from groundwater sources. Water used by SCYI for process and potable water needs is derived solely from groundwater sources. SCYI's water well production field, which consists of five wells, is located about 2,300 ft to 7,000 ft north to northwest of the facility. Only four of the wells are presently being used. The current pumping rate from the well field is less than 600 gpm. The facility production wells and other water supply wells in Yabucoa valley are upgradient of the SCYI

facility. The high total dissolved solids content of the water at the Dock Area makes it unlikely that it would be used for drinking water purposes. Therefore, there are no downgradient receptors likely to be impacted by groundwater contamination.

Groundwater Exposure Evaluation

The groundwater data from the RFI show that the impact of contamination at the SCYI facility on human health via the groundwater pathway appears to be insignificant. Water supply wells for industrial and drinking water supplies are located upgradient of the facility, hence the exposure pathway to receptors is incomplete. Tidal effects and pumping from the water supply well field do not appear to significantly effect the groundwater flow direction at the facility.

The migration to groundwater pathway appears to be incomplete. As previously discussed, at locations where the soil quality exceeded migration to groundwater RBSLs, no detections occurred in groundwater above screening levels.

FPH was observed on the water table at five SWMUs: the Northeast Refinery Area (SWMU 40), the East API Separator (SWMU 3), the Watery Oil Separator (SWMU 43), the Main Dock Sump (SWMU 33), and the Barge Dock Sump (SWMU 34). Residual product was also observed in the soil at the East Aisle Ditch (SWMU 45). Since the free product is in the subsurface with no surface exposure, there is no exposure to on-site workers. Construction workers may be exposed to FPH during subsurface construction activities. However, the facility Health and Safety Plan, which is in effect, contains procedures for construction workers, including requiring appropriate personal protection equipment (PPE) and air monitoring of work areas prior to entry, that will preclude direct contact with FPH.

7.2.3 Surface Water Pathway

The potential impact to human health from exposure to surface water contamination is evaluated in this section. Surface water transport mechanisms, human exposure pathways, and receptors are identified in the evaluation.

The surface water bodies nearest to the SCYI facility are Lajas Creek and Santiago Creek. Lajas Creek flows along the eastern border of the Refinery Area. Santiago Creek borders the Refinery Area to the north, flows in a northeasterly direction, and discharges into the Caribbean Sea north

of the Dock Area. A small unnamed creek flows generally east-west near the northern border of the Tank Farm Area. A second small unnamed creek runs in a northeasterly direction south of the Tank Farm Area. There are no known agricultural or industrial users of these creeks.

Yabucoa Bay of the Caribbean Sea, which is located east of the facility, is used as a recreational area. Lucia Beach, which is located about 2400 ft east of the Tank Farm Area and about 2100 ft south of the Dock Area, is the closest recreational beach. Fishing is also a characteristic activity in coastal areas of Puerto Rico.

Only two surface water intakes are located within a 3 mile radius of the SCYI facility, according to available information (AMAI, 1994). These intakes are located about 2.8 miles east and upstream of the facility. Approximately 4,000 million gallons per year are drawn from the Guayanés River by Central Roig for sugarcane processing during the months of January through May (SCYI Part B Permit Application, 1985). During the remainder of the year, no water is systematically removed from the river. The Guayanés River, the largest inland surface water body in the valley, is located approximately 1.4 miles north of the Refinery Area. It discharges to the Caribbean Sea north of the Dock Area. There are no apparent tributaries to the Guayanés River which emanate from the SCYI facility.

Sources of Contamination

Sources of contamination that could potentially impact surface water resources in the SCYI area would be runoff from soil contaminated by petroleum products containing hazardous constituents, contaminated groundwater discharge to nearby surface water bodies, and potential migration of FPH to the surface water.

As discussed above, soil runoff is not a likely exposure pathway due to the limited areas of surface soil impact. Also, the design of the SCYI stormwater collection system effectively removes this pathway.

Surface water sampling in Lajas Creek adjacent to the Northeast Refinery Area (SWMU 40) did not show any detections. Surface water sampling adjacent to the Main Dock Sump (SWMU 33), as discussed in Section 5.16.3, did not appear to show any evidence of a contaminant release.

Transport Pathway

The main transport pathway is surface water transport within creeks and groundwater discharge to surface water. Measurements for groundwater and surface water interaction at the Northeast Refinery Area (SWMU 40) discussed in Section 2.9 generally show that surface water from Santiago Creek recharges the groundwater and that groundwater discharges to Lajas Creek. Since surface water sampling results for Lajas Creek showed no detections, and no apparent impact occurs to the surface water adjacent to the Main Dock Sump (SWMU 33), groundwater to surface water impact is not indicated. The surface water sampling results also show that surface water transport within Lajas Creek is not an exposure pathway since no constituents were detected above human health screening levels.

SCYI implemented preventative measures for flood control which minimizes the chance for transport by flood conditions. These preventative measures, which consisted mainly of the construction of levees, effectively removed the SCYI facility from the 100-year floodplain.

Visual observations have been performed on a weekly basis at Lajas and Santiago Creeks since April 2003. Visual observations have also been performed on a weekly basis at the shoreline opposite the Main Dock Sump since January 2001. No FPH or product sheen has been observed at either location, which indicates that FPH has not migrated to surface water and that this pathway is not complete.

Exposure Pathways

Human exposure pathways considered are ingestion and dermal contact with potentially contaminated surface water. However, as discussed above, no impact to surface water is indicated.

Receptors

Surface water receptors include people in the area who may use surface water for drinking water or agricultural purposes. Since there are no surface water intakes located downstream of the SCYI facility, there are no surface water receptors.

Surface water in the Yabucoa valley is used for agricultural purposes on a seasonal basis. However, there are no known agricultural or industrial users of the creeks downstream of the SCYI facility.

Lucia Beach, which is located about 2400 ft east of the Tank Farm Area and about 2100 ft south of the Dock Area, is the closest recreational beach. Groundwater from the facility does not flow toward the beach, however, as shown in the groundwater flow maps of Figures 2-17 and 2-18. Hence, there is no completed pathway for groundwater to surface impact to the beach. Lucia Beach is also situated on the opposite side of the Turning Basin from the Dock Area. As discussed above, no apparent impact to seawater is indicated.

Surface Water Exposure Evaluation

The impact of potential contamination at the SCYI facility on human health via the surface water pathway appears to be insignificant. The stormwater collection system at the facility effectively prevents contaminated runoff from impacting surrounding areas. Streams downstream of the facility are not being used for public water supply or industrial uses. Additionally, there are no known agricultural users of surface water downstream of the facility. Dermal contact is unlikely because nearby streams are not used for recreational purposes. Long-term visual FPH observations at Lajas Creek and the Turning Basin show the absence of FPH or sheen, which indicates that FPH does not impact the surface water. Also, surface water sampling results for Lajas Creek and the Turning Basin adjacent to the Main Dock Sump (SWMU 33) do not indicate any apparent impact to human health, including at nearby Lucia Beach.

7.2.4 Air Pathway

The potential impact to human health from exposure to air contamination is evaluated in this section. Air transport mechanisms, human exposure pathways, and receptors are identified in the evaluation.

The predominant wind direction in Yabucoa valley is from the east. Air pathways considered are exposure from vapor or fugitive dust generation, and migration of vapors to indoor air.

Sources of Contamination

Prior drippage or accidental spillage of oil and petroleum products to the surface soil is the primary source of potential contamination at the SCYI facility that would affect the air pathway. However, no contamination above outdoor air screening levels for inhalation of volatiles or fugitive dust occurs in soil at any of the SWMUs.

Migration of vapors to indoor air from contaminated groundwater is also a potential source. An unoccupied building occurs north and upgradient of the Main Dock Sump (SWMU 33). This building was used in the past by Dock Area personnel for incidental purposes. The building was severely affected by Hurricane Georges in October 1998 and since then has no longer been in use. The building is located about 100 ft upgradient of well MDS-4 at which volatile constituents (benzene, naphthalene, and 2-methylnaphthalene) were detected. Groundwater sampling results at well MDS-3, which is upgradient of well MDS-4 and closer to the building, shows non-detect for these constituents, however. Due to the distance between the groundwater plume and the building, and the absence of volatile constituents at well MDS-3, no impact to indoor air is indicated.

No other occupied buildings at the facility occur within 100 ft of a groundwater plume containing volatile constituents above groundwater to indoor air screening levels.

Transport Pathway

Since there are no contaminant sources above outdoor air screening levels for inhalation of volatiles or fugitive dust, a contaminant transport pathway is not applicable.

Migration from contaminated groundwater to indoor air is a potential transport pathway. However, as discussed above, no impact to buildings is indicated.

Exposure Pathways

Since no contamination above outdoor air screening levels occurs in soil at any of the SWMUs, the exposure pathway for outdoor inhalation of volatiles or fugitive dust is incomplete.

As discussed above, exposure from migration of volatiles to indoor air from groundwater contamination is an incomplete pathway.

Receptors

Potential receptors are on-site workers and off-site populations downwind of potentially contaminated areas. However, since levels of contaminants in surface soil do not exceed outdoor air screening levels for outdoor inhalation of volatiles or fugitive dust, no impact is indicated. Also, the migration of vapors from groundwater to indoor air does not pose an impact as discussed above.

Air Exposure Evaluation

Since contaminants levels in surface soil do not exceed outdoor air screening levels for outdoor inhalation of volatiles or fugitive dust, no impact to human health is indicated.

Exposure from migration of vapors from contaminated groundwater to indoor air is not a completed pathway. Hence, no impact to human health is indicated.

7.3 Ecological Evaluation

This section describes the ecological setting at the facility. An ecological screening level analysis was also performed by comparing RFI data with appropriate ecological screening levels (ESLs) for soil, surface water, and sediment.

7.3.1 Ecological Setting

The ecological setting in the vicinity of the SCYI facility is described in this section. The description includes a discussion of surface water features and ecological features on the National Oceanic and Atmospheric Administration (NOAA) environmental sensitivity and U.S. Fisheries and Wildlife Service (USFWS) maps for the facility area. Endangered and threatened species potentially occurring in the area are also discussed. Figures 2-1 and 2-2 show the general location of the facility in the Yabucoa area.

Agricultural and sugar cane fields generally surround the facility to the north, east, and west. Route 901 borders the Refinery Area to the south. Route 53 traverses between the Refinery and Tank Farm Areas. Sugar cane fields are to the south of the Tank Farm Area and a palm tree grove and beach are to the south of the Dock Area. A mountainous area is situated further south of the facility. The town of Yabucoa is located about 1 mile west of the facility.

The Yabucoa area is within a subtropical moist forest area (USGS, 1998). Most of the subtropical moist forest zone has been cleared of forest because the region's climatic conditions and soils are generally favorable for agriculture. Only small, scattered pieces of the original forest remain.

Surface Water Features

The main inland surface water feature of the Yabucoa valley is the Guayanés River, which is located about 1.4 miles northeast of the SCYI facility. The Guayanés River, which flows mainly along the east-west axis of Yabucoa Valley, discharges to the Caribbean Sea north of the Dock Area. Surface water flow in the valley is generally from west to east toward the sea.

The nearest surface water features to the facility are Lajas Creek, which runs along the eastern border of the Refinery Area, and Santiago Creek, which runs along the northern border of the Refinery Area. Lajas Creek subsequently enters Santiago Creek about 300 feet north of the Refinery Area. Santiago Creek runs eastward along the northern part of the Refinery Area and discharges to the Caribbean Sea about 1.5 miles to the east. A small unnamed creek runs generally east-west near the northern border of the Tank Farm Area. This creek is also a tributary to Santiago Creek. A second small unnamed creek runs in a northeasterly direction south of the Tank Farm Area. This creek discharges directly to the Caribbean Sea. None of the rivers or streams in the valley are navigable by large vessels. In the facility area, Santiago and Lajas Creeks are shallow with water depths less than about a foot.

The largest surface water body in the area is Yabucoa Bay of the Caribbean Sea, which borders the Dock Area and is about 1.5 miles east of the Refinery Area. In the Dock Area, a small man-made inlet from the Caribbean Sea, herein referred to as the Turning Basin, is used by tanker ships for loading/unloading operations. The Turning Basin is connected to Yabucoa Bay.

As discussed in Section 2.4, annual rainfall in the area averages about 78 inches. The maximum tidal range for the Yabucoa Bay area, as discussed in Section 2.10, is about 1.6 ft.

Regional Plant and Wildlife

The description below of the regional plant and wildlife in Puerto Rico is summarized from a publication by the USGS (1998).

Puerto Rico is rich in plant life. Puerto Rico has 539 species of native trees. Most native trees in Puerto Rico are protected in natural or near-natural forests on public forest lands and parks.

Puerto Rico has no native freshwater fishes; it does, however, support 24 established non-indigenous introductions as well as 60 peripheral marine invaders.

Fifty reptiles and twenty-three amphibians are known from Puerto Rico and adjacent waters. Among the amphibians, 15 species are endemic, and 4 have been introduced. Puerto Rico's 18 indigenous amphibians include the ridge-headed toad, the common mud frog, and 16 species of tiny frogs commonly called coquis. There are 29 endemic reptiles and 2 introduced species. Puerto Rico's 50 reptilian species include 48 indigenous forms: 33 lizards (2 extinct), 8 snakes, 1 freshwater turtle, 1 land tortoise (extinct), and 5 sea turtles.

A total of 239 native bird species live in Puerto Rico. In addition, many non-indigenous bird species from other areas of the world were introduced to the islands over the last 200 years. The rate of introduction of non-indigenous birds has greatly increased in recent decades; these additions have increased the Puerto Rico's total number of species by 37.

Puerto Rico has no large wild mammals. The mongoose was brought in to control rats on sugar cane plantations. Bats are the only native terrestrial mammals left on Puerto Rico. Puerto Rico has 13 species of bats. Ten of the thirteen extant bat species in Puerto Rico are cave dwellers.

The native ecosystem of Puerto Rico has been seriously disrupted by the introduction of many non-indigenous plant and animal species. At least 118 non-indigenous plant species are reproducing in Puerto Rico. In addition, an undetermined (but likely large) number of invertebrates have become established in Puerto Rico. The non-indigenous vertebrate faunas are

better known for the islands, with 24 fishes, 2 reptiles, 4 amphibians, more than 37 birds, and 13 mammals established in breeding populations.

Wetland Features

The U.S. Fisheries and Wildlife Service (USFWS) wetlands map (USFWS, 2005) for the facility area, which is shown in Figure 7-1, shows the following:

- Three palustrine wetland areas (PSS3Fx) north of the facility Refinery Area. These areas are dominated by scrub-shrub and trees, and are semi-permanently flooded. One of the areas occurs within and one of the areas occurs adjacent to the Northeast Refinery Area (SWMU 40).
- A small palustrine wetland (PEM1/UBHx) is identified within the northern part of the facility area. This area is classified as emergent, persistent, and permanently flooded. This area serves as the stormwater surge pond for the facility.
- The Former Equalization Basin, Firewater Basin, and Aeration Basins are shown within the Refinery Area on the wetlands map as PUBHx, which indicates that they are permanently flooded. These basins are man-made and used for various facility purposes and are not actual wetlands.
- An emergent, persistent, temporarily flooded palustrine wetland (PEM1A) occurs adjacent to and north of the Tank Farm and Dock Areas.
- An emergent, persistent, seasonally flooded palustrine wetland (PEM1C) occurs adjacent to and south of the Tank Farm Area.
- An emergent, persistent, semipermanently flooded palustrine wetland (PEM1F) occurs to the southeast of the Tank Farm Area.
- A forested and temporarily flooded palustrine wetland (PFO3A) also occurs north of the Dock Area.

- The Turning Basin of the Dock Area is classified by the USFWS as a subtidal estuarine habitat (E1UBLx). However, based on review of topographic maps, the influence of freshwater in this area appears limited.

With the exception of the Northeast Refinery Area (SWMU 40) as discussed above, none of the wetland areas occur within or adjacent to any of the SWMUs.

Environmentally Sensitive Features

The Environmental Sensitivity Index Map (NOAA, 2000, Map PR-54) for the Yabucoa area, which is presented in Figure 7-2, shows the general ecological setting in the vicinity of the SCYI facility. Freshwater marshy and swampy areas are located north of the Refinery Area in two small zones adjacent to Santiago Creek. Freshwater marshy areas are also located to the south of the Tank Farm Area. The shoreline bordering the Dock Area consists of a sheltered man-made area south of the Main Dock Sump (SWMU 33), rip-rap, and fine- to medium-grained sand beaches. Sheltered tidal flats up to 0.5 miles long with vegetated low banks occur near the terminus of Santiago Creek north of the Dock Area. Further north, near the terminus of the Guayanés River, a 0.25-mile long sheltered tidal flat also occurs. An area of submerged sea grass within an exposed wave-cut platform occurs in the Caribbean Sea east of the Dock Area. A shelf edge reef occurs about 1.6 miles to the east of the Yabucoa Bay shoreline.

The Caribbean Fisheries Management Council (1991) reported that there is little coral growth in Yabucoa Bay apart from an annular reef in the southern part of the bay. This reef has few living corals possibly due, in part, to river runoff. ANSP (1982) also note that the poor coral reef growth in Yabucoa Bay is most likely due to high levels of sedimentation and turbidity in Yabucoa Bay, which is likely related to the large suspended sediment load carried to the bay by the Guayanés River.

A number of plant and animal species have been identified by NOAA (2002, Map PR-54) in the following areas of Yabucoa:

- Area 263 on Figure 7-2, which is an upstream wetlands area located about 1 mile northwest of the facility Refinery Area.

- Area 264 on Figure 7-2, which is a sheltered tidal flat area within the terminus area of Santiago Creek, which is located north of the Dock Area.
- Beaches, near shore and shelf waters, and offshore waters.

Table 7-6 shows the plant and animal species potentially present in the above areas as identified by NOAA (2002, Map PR-54). The table also includes information concerning whether any of the species are endangered or threatened on either State or federal lists. Protected species information presented by NOAA was collected, compiled, and reviewed with the assistance of biologists and resource managers from Puerto Rico Department of Natural and Environmental Resources (DNER), USFWS, and many other agencies, organizations, and groups. Additionally, the table includes four endangered or threatened species not listed by NOAA, but identified using the USFWS Endangered Species List. These species include the Brown pelican, Antillean manatee (mammal), Coqui guajon (amphibian), Puerto Rican Boa (reptile), Leatherback sea turtle, Hawksbill sea turtle, and Green sea turtle as identified by a USFWS database search discussed below. Facility personnel have visually observed the presence of manatees in the Turning Basin of the Dock Area. However, DNER (Mr. Luis Beltran, 2005, personal comm.) notes that although sightings of manatees have been documented in the Yabucoa Bay area, the bay area, including the Turning Basin, is not considered a regular living environment, but rather a transit area to somewhere else.

A database search provided by the USFWS and NOAA, showing threatened and endangered species and critical habitats within a one-mile radius of the facility, is provided in Appendix K. NOAA did not identify any critical habitats in the vicinity of the facility. Table 7-6 incorporates the results of the database search.

7.3.2 Ecological Screening Analysis

An ecological screening analysis was performed by comparing RFI data with appropriate ecological screening levels (ESLs) for soil, surface water, and sediment.

The media for which RFI sample results are available are surface soil at the various SWMUs, surface water at the Main Dock Sump (SWMU 33), and surface water and sediment at Lajas Creek adjacent to SWMU 40. Possible exposure pathways for ecological receptors present at the facility include the direct ingestion of contaminated surface soil, surface water, and/or sediments

and the indirect ingestion of contaminated biota in the food chain. Exposure of biota to subsurface soils and airborne contaminants (through volatilization or fugitive dust emissions) via inhalation or dermal contact is not expected to represent a significant exposure pathway. Ecological receptors are also not anticipated to be directly exposed to groundwater contaminants, although the evaluation of surface water and sediment indirectly evaluate contaminants transported through groundwater discharge.

7.3.2.1 Data Sources

Data sources from the RFI for soil, sediment, and surface water that were used for ecological screening analysis were as follows:

- Surface soil data from ten SWMUs (SWMUs 2, 3, 34, 35, 36, 38, 39, 40, 44, and 45) were used for the evaluation. As discussed in Section 5.12, surface soil results were not available at SWMU 43. Instead, the shallow subsurface results from sample 43-03 (3-3.5ft) were also used for the evaluation. The RFI work plan did not require sampling of surface soil data at the remaining five SWMUs (SWMUs 14, 17, 18, 33, and 44A) as surface soil was not identified as a potentially affected medium. The soil sampling program and results for the various SWMUs are discussed in Section 5.
- Sediment and surface water data from Lajas Creek were evaluated. The sampling program for Lajas Creek, which consisted of sample collection at two locations, is discussed in detail in Section 5.9.
- Surface water data from the Main Dock Sump (SWMU 33) were evaluated. The sampling program for the Main Dock Sump, which consisted of sample collection at two locations, is discussed in detail in Section 5.16.

7.3.2.2 Ecological Screening Levels

Ecological screening levels for the various sampled media (soil, sediment, and surface water) were obtained from a number of sources, which are described below. ESLs are non-regulatory values used for screening purposes only and are not meant to serve as clean-up levels.

ESLs for surface soil were obtained using the hierarchy of sources as follows:

- For chemicals with Ecological Soil Screening Levels (Eco-SSLs) (EPA, 2006) for one or more endpoints, including the mammalian endpoint, the lowest of the Eco-SSL values for all endpoints was selected.
- For chemicals with Eco-SSLs for endpoints not including the mammalian endpoint, the lowest value of the available Eco-SSLs and the EPA Region 5 ESLs (R5ESL) (EPA, 2003a) was selected.
- For chemicals with no Eco-SSLs, R5ESLs were selected. R5ESLs were mainly determined based on exposure to a masked shrew (*Sorex cinereus*). The shrew is generally a digging species with a small home range. The diet of the shrew is comprised primarily of insects and other invertebrates with small vertebrates and plant matter also consumed. The shrew represents a sensitive indicator for an insectivore species as it would be exposed to contaminants that accumulate in invertebrates, has a small home range, and has a high food intake rate relative to its body weight.

Eco-SSLs for soil are currently available only for certain metals. The selection of ESLs for metals in soil, including the various endpoints, is summarized in Table 7-7. For VOCs and BNAs in soil, R5ESLs were selected as shown in Table 7-8.

ESLs for sediment were obtained from the following source:

- EPA Region 5 sediment screening values (EPA, 2003a). R5ESLs for sediment were mainly determined using an equilibrium partitioning equation and the ecological screening levels for surface water (freshwater).

ESLs for surface water (freshwater) at Lajas Creek were obtained from the following sources:

- Puerto Rico Water Quality Standards (PREQB, 2003) applicable to aquatic life for Class SD waters. Class SD water is applicable to Lajas Creek. Puerto Rico Class SD waters are defined as surface waters intended for use as a raw source of public water supply, propagation and preservation of desirable species, including threatened or endangered species, as well as primary and secondary contact recreation.

- EPA ambient water quality standards for protection of aquatic life in freshwater for continuous exposure (EPA, 2002b). Chronic standards incorporate adverse effects on growth, reproductive success, and survival over all or most of the lifecycle of the test organism. EPA ambient water quality standards for continuous exposure are also protective of acute exposure.
- EPA Region 5 surface water screening values for freshwater (EPA, 2003a). EPA Region 5 screening values were compiled from various water quality criteria documents and represent the chronic ambient water quality criteria values for protection of aquatic life.

ESLs for surface water (saltwater) were obtained from the following sources:

- Puerto Rico Water Quality Standards (PREQB, 2003) applicable to aquatic life for Class SC waters. Class SC water is applicable to the surface water adjacent to the Main Dock Sump (SWMU 33) and Barge Dock Sump (SWMU 34). Puerto Rico Class SC waters are defined as coastal and estuarine waters intended for use in primary and secondary contact recreation, and for propagation and preservation of desirable species, including threatened or endangered species. As discussed in Section 5.1.2, the Puerto Rico Water Quality Standard (PREQB, 2003) for arsenic of 1.4 ug/L appears to have a typographic error that incorrectly lists it as relating to protection of aquatic life. The appropriate water quality standard for protection of aquatic life is 36 ug/L (Criteria Continuous Concentration in EPA, 2002b).
- EPA ambient water quality standards for protection of aquatic life in saltwater for continuous exposure (EPA, 2002b). Chronic standards incorporate adverse effects on growth, reproductive success, and survival over all or most of the lifecycle of the test organism. EPA ambient water quality standards for continuous exposure are also protective of acute exposure.
- EPA Region 4 surface water screening values for saltwater (EPA, 2003b). EPA Region 4 screening values were compiled from various water quality criteria documents and represent the chronic ambient water quality criteria values for protection of aquatic life.

7.3.2.3 Constituents of Potential Ecological Concern

In this section, media concentrations from data sources presented in Section 7.3.2.1 are compared to ESLs described in Section 7.3.2.2. The comparison to ESLs was made for maximum detected contaminant concentrations in surface soil, sediment, and surface water, to determine which contaminants exceed ESLs and may be constituents of potential ecological concern. The SWMUs at which any exceedances occurred are also identified.

Surface Soil

A list of maximum detected concentrations of constituents detected at the facility during the RFI in surface soil is presented in Table 7-8. ESLs for surface soil are included in the table for comparison. Data tables for surface soil presented in Section 5 for various SWMUS were also used for the evaluation.

Acetone (2600 DJ ug/kg) and di-n-butyl phthalate (170 J ug/kg) exceeded ESLs (2500 ug/kg and 150 ug/kg, respectively) at SWMU 40. The exceedance for acetone occurred only at sample location 40-02 at a sample depth of 1.5-2 ft bgl. The exceedance for di-n-butyl phthalate occurred only at sample location 40-03 at a sample depth of 1.5-2 ft bgl. Naphthalene (260 J ug/kg) exceeded its ESL of 99.4 ug/kg at the Dissolved Air Flotation Unit (SWMU 36). The exceedance occurred only at sample location 36-02 at a depth of 1-1.5 ft bgl. None of these constituents exceeded ESLs at any other SWMU, which shows that the potential impact is limited to the relatively small area of the affected SWMUs. Additionally, acetone and phthalates, which include di-n-butyl phthalate, are common laboratory contaminants, and their detection is likely due to laboratory artifacts unrelated to site conditions. No other VOCs or BNAs exceeded ESLs.

Cadmium, chromium, cobalt, lead, nickel, and vanadium in surface soil exceeded ESLs at certain SWMUs. It should be noted that background levels of cadmium, chromium, cobalt, lead, and vanadium also exceed ESLs.

Cadmium (0.38 B mg/kg) slightly exceeded its ESL of 0.36 mg/kg at one location at SWMU 40, but did not exceed its background level of 0.8 mg/kg. Chromium (38.2 mg/kg) exceeded its ESL of 26 mg/kg at one location at SWMU 40, which slightly exceeded its background level of 31 mg/kg. Cobalt (15.8 mg/kg) exceeded its ESL of 13 mg/kg at two locations at SWMU 35, but

not its background level of 17 mg/kg. Lead (16.8 J to 43.9 J) exceeded its ESL of 11 mg/kg at five SWMUs (one location at SWMU 3, one location at SWMU 34, two locations at SWMU 36, one location at SWMU 39, and two locations at SWMU 40. The lead ESL exceedances were below the background level of 32 mg/kg at SWMUs 34 and 39, at one location at SWMU 36, and at one location at SWMU 40. Nickel (49.1 and 233 mg/kg, respectively) exceeded its ESL of 13.6 mg/kg at two locations at SWMU 39 and at two locations at SWMU 40. The nickel ESL exceedance at one location at SMWU 39 was below the background level of 28 mg/kg. Vanadium (27 to 577 mg/kg) exceeded its ESL of 7.8 mg/kg at all eleven SWMUs. However, vanadium did not exceed its background level of 139 mg/kg, except for the two locations (466 and 577 mg/kg) at SWMU 40.

Sediment

Tables 5-55 and 5-56 show the results of the sediment sampling for VOCs and PAHs at Lajas Creek including corresponding ESLs. The results show that only acetone was detected. Acetone (19.9 ug/kg) exceeded its ESL of 9.9 ug/kg. However, acetone is a common laboratory contaminant, and its detection is likely due to a laboratory artifact unrelated to site conditions.

Surface Water

Tables 5-57 and 5-58 show the results of the surface water sampling for VOCs and BNAs at Lajas Creek including corresponding ESLs for freshwater. Lajas Creek is adjacent to the Northeast Refinery Area (SWMU 40). The surface water results for Lajas Creek show that no VOCs or BNAs were detected.

Tables 5-114, 5-115, and 5-116 show the results of the surface water sampling for VOCs, BNAs, and metals at the Main Dock Sump (SWMU 33) including corresponding ESLs for saltwater. The surface water results for the Main Dock Sump show that no VOCs or BNAs were detected. Also, no metals exceeded ESLs.

7.3.2.4 Comparison of ESLs to Non-Detects

This section presents a discussion of a comparison of ESLs to detection limits for non-detected constituents (non-detects) in surface soil, sediment, and surface water. The purpose is to evaluate the uncertainty and protectiveness with respect to the ESLs that are associated with the analytical

methods used for the RFI and any associated matrix interferences. The uncertainty analysis of the detection limits for non-detects with respect to ESLs is being performed as per EPA guidance (EPA, 1997).

Table 7-9 presents a list of maximum detection limits for non-detects that exceed ESLs for surface soil sample results at relevant SWMUs. For simplicity, constituents not detected during the RFI and with detection limits that did not exceed ESLs are not included on the table.

Sediment ESLs presented in Table 5-55 for VOCs and Table 5-56 for PAHs were compared to detection limits shown in the tables for the evaluation. Surface water ESLs presented in Tables 5-57 and 5-114 for VOCs, Tables 5-58 and 5-115 for BNAs, and Tables 5-116 for metals were compared to detection limits shown in the tables for the evaluation.

Surface Soil

For VOCs in surface soil, only the detection limit for carbon disulfide (120 U ug/kg) at SWMU 45 exceeded its ESL of 94.1 ug/kg. The magnitude of the exceedance (by a factor of about 1.3) is not significant.

Maximum detection limits for site related BNAs [benzo(a)pyrene, 2-methylnaphthalene, and naphthalene] in surface soil exceeded respective ESLs at several SWMUs as shown on Table 7-9. The maximum detection limit for benzo(a)pyrene (3800 UJ ug/kg) at SWMU 2 exceeded its ESL of 1520 ug/kg by a factor of 2.5. The maximum detection limit for 2-methylnaphthalene (3800 UJ ug/kg) at SWMU 2 exceeded its ESL of 3240 ug/kg by a factor of about 1.2. The maximum detection limit for naphthalene (3800 UJ ug/kg) at SWMU 2 exceeded its ESL of 99.4 ug/kg by a factor of about 38. The magnitudes of the exceedances are not considered to be significant with respect to any overall uncertainty in the soil screening evaluation. Maximum detection limits for other BNAs shown on Table 7-9 exceeded ESLs; with the exception of bis(2-ethylhexyl)phthalate and di-n-butyl phthalate, none of the other BNAs were detected at the facility during the RFI. Phthalates are common laboratory contaminants.

For metals in surface soil, maximum detection limits for antimony, cadmium, and selenium exceeded respective ESLs at all eleven SWMUs shown in Table 7-9. The maximum detection limit for antimony (8.6 UJ mg/kg) at SWMU 45 exceeded its ESL of 0.27 mg/kg by a factor of about 32. The maximum detection limit for cadmium (0.47 U mg/kg) at SWMU 45 exceeded its ESL of 0.36 mg/kg by a factor of about 1.3. The maximum detection limit for selenium (1.1 UJ

mg/kg) at SWMUs 2 and 38 exceeded its ESL of 0.0276 mg/kg by a factor of about 40. The analytical method achieved the lowest possible detection limits and there was no evidence of matrix interference. The magnitudes of the exceedances are not considered to be significant with respect to any overall uncertainty in the soil screening evaluation.

Eco-SSL were derived by a multi-stakeholder workgroup consisting of federal state, consulting, industry and academic participants led by the EPA (EPA, 2005). The workgroup derived the Eco-SSLs using standardized procedures for literature review, toxicity data collection, and data evaluation. As such, Eco-SSLs are preferred over other screening levels, such as R5ESLs, which do not share the level of review. Eco-SSLs are available for all program metals, with the exception of mercury, nickel, and selenium. R5ESLs were therefore used for these three metals. Table 7-7, which summarizes the selection of ESLs, shows that Eco-SSLs are higher than corresponding R5ESLs. Consequently, it may be that when Eco-SSLs are eventually derived for mercury, nickel, and selenium, that they will be higher than the R5ESLs. Thus, there is an uncertainty in the R5ESLs for metals used for the ecological screening evaluation, particularly regarding selenium, which has a very low R5ESL of 0.0276 mg/kg.

Sediment

For VOCs in sediment shown in Table 5-55, maximum detection limits for acetone, bromomethane, and 1,1-dichloroethane exceeded respective ESLs by factors ranging from 1.3 to 13.5. The analytical method achieved the lowest possible detection limits and there was no evidence of matrix interference. The magnitudes of the exceedances are not considered to be significant with respect to any uncertainty in the soil screening evaluation. Additionally, with the exception of acetone, which is a common laboratory contaminant, none of these constituents have been detected at the facility.

For PAHs in sediment shown in Table 5-56, maximum detection limits for acenaphthene and acenaphthylene exceeded respective ESLs by a factor up to 1.3. The analytical method achieved the lowest possible detection limits and there was no evidence of matrix interference. The magnitude of the exceedance is not significant.

Surface Water

For VOCs in surface water shown in Tables 5-57 and 5-114, all detection limits were below ESLs.

For BNAs in surface water (freshwater) shown in Tables 5-58, the analytical method achieved the lowest possible detection limits and there was no evidence of matrix interference. However, detection limits for certain compounds exceeded ESLs. Exceedances for PAHs [anthracene, benzo(a)anthracene, benzo(a)pyrene, dibenzofuran, fluoranthene, fluorene, and pyrene] occurred by factors ranging from 1.1 (fluoranthene) to 150 [benzo(a)pyrene]. Exceedances for other compounds [bis(2-ethylhexyl)phthalate, 4-bromophenol phenyl ether, 2-chloronaphthalene, 3,3'-dichlorobenzidine, and hexachlorobutadiene] ranged by factors ranging from 1.2 to 40. The exceedance for hexachlorobenzene was by a factor of 7000. With the exception of several PAHs and bis(2-ethylhexyl)phthalate, none of the other compounds have been detected at the facility during the RFI. The magnitudes of the exceedances for the constituents detected during the RFI are not considered to be significant with respect to any overall uncertainty in the soil screening evaluation.

For BNAs in surface water (saltwater) shown in Tables 5-115, the analytical method achieved the lowest possible detection limits and there was no evidence of matrix interference. However, detection limits for fluoranthene, hexachlorobutadiene, and hexachlorocyclopentadiene exceeded ESLs by factors of 1.4, 6.9, and 314, respectively. Only fluoranthene has been detected at the facility during the RFI and the magnitude of the exceedance is not significant.

For metals in surface water shown in Table 5-116, the analytical method achieved the lowest possible detection limits and there was no evidence of matrix interference. However, the detection limit for mercury exceeded its ESL by a factor of 4, which is not considered to be significant in terms of overall uncertainty.

8.0 Findings and Conclusions

This section presents the findings and conclusions of the field investigation at the 16 solid waste management units (SWMUs) investigated during the RFI.

Overview

- As part of the RCRA Facility Investigation being conducted at the SCYI facility, 16 SWMUs were investigated in accordance with the USEPA-approved RFI Work Plan. The objectives of conducting the field investigation are summarized below:
 - Identify hazardous constituents and their concentrations in soil and/or groundwater at each SWMU
 - Determine the potential for contaminant migration by assessing site-specific and regional characteristics that are likely to affect contaminant migration
 - Acquire sufficient data to characterize environmental contamination at the SWMUs to support interim or long term corrective measures, if necessary
 - Acquire sufficient data to assess any potential risk to human health and the environment.
- The RFI objectives were achieved utilizing a combination of soil sampling, groundwater sampling, visual inspection and various field screening techniques. The initial field investigation was conducted between May and September 1996. Confirmatory groundwater samples were collected at certain SWMUs in January and February, 1997. Supplemental investigation activities were conducted between January and June 2003 and between February and March 2005. A total of 91 soil samples were collected for VOC, BNA and/or metals analysis. Eight soil samples were collected for physiochemical analysis. A total of 146 soil samples were collected for field screening by immunoassay. The soil samples were collected from various depths at 68 locations. A total of 58 groundwater monitoring wells were installed. The wells were used for groundwater level observations, collection of groundwater samples, and/or FPH delineation and thickness measurements. Sediment and surface water sampling was performed at two locations at

Lajas Creek. Surface water sampling was also performed at two locations at the Main Dock Sump (SWMU 33).

Hydrogeological Characterization

- The silty and clayey nature of the surface soils in the Refinery Area above the water table, and the mechanisms that influence the fate and transport of organic and inorganic contaminants, retard the rate of contaminant transport to the groundwater system. In the Tank Farm and Dock Areas, the soil is sandy and more permeable and contaminant transport is less retarded.
- Based on groundwater level measurements collected during the RFI, the horizontal groundwater flow direction in the vicinity of the SCYI refinery is generally to the east toward the Caribbean Sea. Localized flow in the Refinery Area is to the north and northeast; to the east and northeast within the Tank Farm Area; and to the east and southeast within the Dock Area.
- The vertical hydraulic gradient at the Northeast Refinery Area (SWMU 40) varied seasonally between upward and downward, although the upward direction was more frequent. In the Tank Farm Area, the vertical gradient at the East API Separator (SWMU 3) was downward. At the Watery Oil Separator (SWMU 43) also in the Tank Farm Area, the vertical gradient varied seasonally between upward and downward, although the downward direction was more frequent. Expected groundwater discharge to the Caribbean Sea suggests an upward vertical gradient in the Dock Area.
- Measurements for groundwater and surface water interaction at the Northeast Refinery Area (SWMU 40) generally show that surface water from Santiago Creek recharges the groundwater and that groundwater discharges to Lajas Creek. Occasional flow direction reversals, mainly at the area of gauges SG-2 and SC-1 in Santiago Creek, were observed.
- Average horizontal groundwater velocities were estimated to be about 0.01 ft/day in the Refinery Area, 0.07 ft/day in the Tank Farm Area, and 0.8 ft/day in the Dock Area. The rate of transport of any contaminants identified at the SCYI facility is less than the average groundwater velocity due to the physical and chemical properties of the compounds.

Soil Sampling Results

- No VOCs were present in surface soil (0-2 ft below ground level) or subsurface soil (greater than 2 ft below ground level) at any of the SWMUs at levels above direct-contact RBSLs. Methylene chloride exceeded its migration to groundwater soil RBSL of 20 ug/kg in subsurface soil at one sampling location at the East API Separator (SWMU 3)(48 J ug/kg) and at one location at the Watery Oil Separator (SWMU 43) (23 J ug/kg). Methylene chloride is a common laboratory contaminant, and its detection in soil is likely related to a laboratory artifact. Additionally, methylene chloride was not detected at the downgradient groundwater monitoring wells at the Watery Oil Separator (WOS-4A and WOS-5A). At the East API Separator, since the methylene chloride concentration does not significantly exceed its migration to groundwater RBSL, and since this constituent has not been detected at any of the wells at the unit or at downgradient wells [wells 45-01 and 45-02 of the East Aisle Ditch (SWMU 45) and wells at the Barge Dock Sump (SWMU 34)], this constituent in soil has had no significant impact on groundwater.
- No BNAs were detected in the surface or subsurface soil above direct-contact RBSLs, except for benzo(a)pyrene in surface soil at one SWMU and in subsurface soil at three SWMUs. Benzo(a)pyrene exceeded its direct-contact RBSL of 210 ug/kg in surface soil at the East API Separator (SWMU 3)(230 J ug/kg) at one location. Benzo(a)pyrene exceeded its direct-contact RBSL of 210 ug/kg in subsurface soil at one location at the Dissolved Air Flotation Unit (SWMU 36)(400 J ug/kg), at one location at the Northeast Refinery Area (SWMU 40)(2600 J ug/kg), and at one location at the East API Separator (SWMU 3)(1000 J ug/kg). At three locations at the Barge Dock Sump (SWMU 34)(110,000 ug/kg), 2-methylnaphthalene (concentrations ranging from 31,000 D to 110,000 D ug/kg) in subsurface soil exceeded its migration to groundwater RBSL of 17,000 ug/kg, but was not detected in the groundwater above its screening level.
- MSL metals detected in soil above direct-contact RBSLs consisted only of arsenic. Arsenic exceeded its direct-contact RBSL of 1.6 mg/kg in surface soil at the following seven SWMUs: West API Separator (SWMU 2), East API Separator (SWMU 3), Barge Dock Sump (SWMU 34), Slop Oil Tank (SWMU 35), Northeast Refinery Area (SWMU 40), Watery Oil Separator (SWMU 43), and the East Aisle Ditch (SWMU 45). The arsenic levels at these SWMUs ranged from 1.8 B to 7.3 mg/kg, which were below the

background level of 8.7 mg/kg. Arsenic exceeded its direct-contact RBSL of 1.6 mg/kg in subsurface soil at the following nine SWMUs: West API Separator (SWMU 2), East API Separator (SWMU 3), Barge Dock Sump (SWMU 34), Dissolved Air Flotation (DAF) Unit (SWMU 36), Hazardous Waste Mixing Box (SWMU 39), Northeast Refinery Area (SWMU 40), Watery Oil Separator (SWMU 43), Ballast Basin Skimmer Area (SWMU 44), and the East Aisle Ditch (SWMU 45). With the exception of one location at the Watery Oil Separator (SWMU 43), the arsenic levels at these SWMUs ranged from 1.7 BJ to 6.1 J mg/kg, which were below the background level of 8.7 mg/kg. At the one location at the Watery Oil Separator (SWMU 43), the arsenic level was 11 mg/kg at a depth of 7-7.5 ft, which only slightly exceeded the background level.

- MSL metals detected in soil above migration to groundwater RBSLs consisted of chromium, nickel, and selenium only at the Northeast Refinery Area (SWMU 40). Chromium (38.2 mg/kg) in surface soil exceeded its migration to groundwater RBSL of 38 mg/kg at one location at SWMU 40. Nickel (153 and 233 mg/kg) in surface soil exceeded its migration to groundwater RBSL of 130 mg/kg at two locations, and in subsurface soil (141 mg/kg) at one location at SWMU 40. Selenium (7.6 J mg/kg) exceeded its migration to groundwater RBSL of 5 mg/kg at one location coinciding with one of the nickel exceedances. The exceedances were not significant. Neither chromium, nickel, nor selenium were detected in groundwater above screening levels at the Northeast Refinery Area, however.

Groundwater Sampling Results

- VOC and BNA contaminants detected in groundwater above screening levels consisted of benzene, naphthalene, and 2-methylnaphthalene at well MDS-4 of the Main Dock Sump (SWMU 33) and 2-methylnaphthalene at well 40-21 of the Northeast Refinery Area (SWMU 40). At well MDS-4, the benzene level was 60 ug/L, which was above its screening level of 5 ug/L. The naphthalene level at well MDS-4 was 21.9 ug/L, which was above its screening level of 6.2 ug/L. The 2-methylnaphthalene levels at wells MDS-4 and 40-21 were 60.1 ug/L and 36.9 ug/L, respectively, which were above the screening level of 24 ug/L. Since naphthalene and 2-methylnaphthalene had not been previously detected at MDS-4 and benzene had been only tentatively detected, and not confirmed, it is likely that a January 31, 2002 hydrocarbon release contributed to the FPH impact at MDS-4. [Note: The most recent quarterly groundwater sampling results from

December 2006, which were reported in Quarterly Progress Report #51, show that benzene and naphthalene are non-detect at well MDS-4. Also, 2-methylnaphthalene at well MDS-4 occurred at 10.3 ug/L (11.9 ug/L in the duplicate), which is below its screening level of 24 ug/L. Also, at well 40-21 in December 2006, 2-methylnaphthalene was detected at 1.4 ug/L (1.3 ug/L in the duplicate), which is below its RBSL of 24 ug/L. Historic results from well 40-21 indicate a decreasing concentration trend for 2-methylnaphthalene.].

- MSL metals detected in groundwater above screening levels consisted only of arsenic at the North Aeration Basin (SWMU 17) and the Barge Dock Sump (SWMU 34). The arsenic level at well AB-1 of the North Aeration Basin (SWMU 17) was 12.3 J ug/L, which exceeded its screening level of 10 ug/L. Arsenic was not detected above its screening level at downgradient wells 40-08, 40-10, 40-11, and 40-21, however. [Note: The recent semiannual groundwater sampling results from April and September 2006 for well AB-1 and downgradient well AB-2, which were reported in Quarterly Progress Report #50, show that total and dissolved arsenic are non-detect, which indicates no impact to groundwater].
- Arsenic occurred at a level of 34.0 ug/L at the Barge Dock Sump (SWMU 34) during the sampling event in April 2003. The arsenic level at well BDS-1, which is the furthest downgradient well at the unit, did not exceed the screening level, however. [Note: The recent semiannual sampling results from September 2006, which were reported in Quarterly Progress Report #50, show that total and dissolved arsenic were detected at well BDS-1 (7.8 B and 9.8 ug/L, respectively) below the MCL of 10 ug/L. Total and dissolved arsenic were also detected at well BDS-2 (29.0 and 33.4 ug/L, respectively) above the MCL. A stable arsenic plume at the Barge Dock Sump is indicated since there are no significant differences from the historic results].
- Arsenic detections above the EPA Region 9 tap water PRG of 0.045 ug/L, but less the MCL screening level of 10 ug/L, occurred at the following five SWMUs: Northeast Refinery Area (SWMU 40), East API Separator (SWMU 3), Dewatering Chamber (SWMU 38), West API Separator (SWMU 2), and Main Dock Sump (SWMU 33). The detected concentration at these SWMUs varied from 2.8 to 7.1 ug/L. At the Watery Oil Separator (SWMU 43) arsenic occurred at concentrations up to and including 10 ug/L. As discussed for the North Aeration Basin (SWMU 17) and the Barge Dock Sump

(SWMU 34) in Sections 5.4 and 5.17, respectively, arsenic exceeded its MCL screening level in groundwater at these two units. It should be noted the 0.045 ug/L tap water PRG is below the reporting limit of available laboratory instrumentation.

- No VOC contamination was detected above groundwater screening levels at deep well 40-14B at the Northeast Refinery Area (SWMU 40), at deep well 03-10B at the East API Separator (SWMU 3), and at deep well WOS-4B at the Watery Oil Separator (SWMU 43). This shows that there has been no migration of any VOCs, which are the more mobile contaminants, to deeper water-bearing zones.
- FPH occurs on the water table at five SWMUs: the Northeast Refinery Area (SWMU 40), the East API Separator (SWMU 3), the Watery Oil Separator (SWMU 43), the Main Dock Sump (SWMU 33), and the Barge Dock Sump (SWMU 34). Residual product was also observed in the soil at the East Aisle Ditch (SWMU 45). The FPH plumes appear to be stable.

Exposure Assessment

- Exposure to on-site workers and construction workers to benzo(a)pyrene above its RBSL of 210 ug/kg in surface soil may occur at a limited area at the East API Separator (SWMU 3). The exposure is not expected to be significant due to the relatively low level of benzo(a)pyrene (230 J ug/kg) and the limited area of the exceedance.
- As discussed above, benzo(a)pyrene in subsurface soil at concentrations ranging from 400 J to 2600 J ug/kg also exceeded the RBSL of 210 ug/kg at limited areas at three SWMUs: the Dissolved Air Flotation Unit (SWMU 36), the Northeast Refinery Area (SWMU 40), and the East API Separator (SWMU 3). Exposure to construction workers during any subsurface construction activities is not expected to be significant due to the concentrations and the limited exposure areas.
- Arsenic exceeded RBSLs in surface soil at surface and/or subsurface soil at nine SWMUs discussed above. With one exception in subsurface soil at the Watery Oil Separator (SWMU 43), all the arsenic levels were below background. The exceedance in subsurface soil at the Watery Oil Separator was also not significantly above background. Any exposure to construction workers is not expected to be significant.

- Construction workers may be exposed during any subsurface construction activities to FPH on the water table at five SWMUs: the Northeast Refinery Area (SWMU 40), the East API Separator (SWMU 3), the Watery Oil Separator (SWMU 43), the Main Dock Sump (SWMU 33), and the Barge Dock Sump (SWMU 34). Residual product was also observed in the soil at the East Aisle Ditch (SWMU 45). Since the free product is in the subsurface with no surface exposure, there is no exposure to on-site workers. However, the facility Health and Safety Plan, which is in effect, contains procedures for construction workers, including requiring appropriate personal protection equipment (PPE) and air monitoring of work areas prior to entry, that will preclude direct contact with FPH.
- The migration from soil to groundwater pathway appears to be incomplete. At locations where the soil quality exceeded migration to groundwater RBSLs, no detections occurred in groundwater above screening levels at the units or at downgradient wells. Hence, there is no evidence of any significant impact.
- The groundwater data from the RFI show that the impact of contamination at the SCYI facility on human health via the groundwater pathway appears to be insignificant. Water supply wells for industrial and drinking water supplies are located upgradient of the facility, hence the exposure pathway to receptors is incomplete. Tidal effects and pumping from the water supply well field do not appear to significantly effect the groundwater flow direction at the facility.
- The impact of potential contamination at the SCYI facility on human health via the surface water pathway appears to be insignificant. The stormwater collection system at the facility effectively prevents contaminated runoff from impacting surrounding areas. Streams downstream of the facility are not being used for public water supply or industrial uses. Additionally, there are no known agricultural users of surface water downstream of the facility. Dermal contact is unlikely because nearby streams are not used for recreational purposes. Long-term visual FPH observations at Lajas Creek and the Turning Basin show the absence of FPH or sheen, which indicates that FPH does not impact the surface water. Also, surface water sampling results for Lajas Creek and the Turning Basin adjacent to the Main Dock Sump (SWMU 33) do not indicate any apparent impact to human health, including at nearby Lucia Beach, which is located about 2400 ft east of the Tank Farm Area and about 2100 ft south of the Dock Area.

- Since contaminants levels in surface soil do not exceed outdoor air screening levels for outdoor inhalation of volatiles or fugitive dust, no impact to human health is indicated. Exposure from migration of vapors from contaminated groundwater to indoor air is not a completed pathway as there are no occupied buildings at the facility within 100 ft of a groundwater plume containing volatile constituents above groundwater to indoor air screening levels.

Ecological Screening Analysis

- Acetone (2600 DJ ug/kg) and di-n-butyl phthalate (170 J ug/kg) exceeded ESLs (2500 ug/kg and 150 ug/kg, respectively) at SWMU 40. The exceedance for acetone occurred only at sample location 40-02 at a sample depth of 1.5-2 ft bgl. The exceedance for di-n-butyl phthalate occurred only at sample location 40-03 at a sample depth of 1.5-2 ft bgl. Naphthalene (260 J ug/kg) exceeded its ESL of 99.4 ug/kg at the Dissolved Air Flotation Unit (SWMU 36). The exceedance occurred only at sample location 36-02 at a depth of 1-1.5 ft bgl. None of these constituents exceeded ESLs at any other SWMU, which shows that the potential impact is limited to the relatively small area of the affected SWMUs. Additionally, acetone and phthalates, which include di-n-butyl phthalate, are common laboratory contaminants, and their detection is likely due to laboratory artifacts unrelated to site conditions. No other VOCs or BNAs exceeded ESLs.
- Cadmium (0.38 B mg/kg) slightly exceeded its ESL of 0.36 mg/kg at one location at SWMU 40, but did not exceed its background level of 0.8 mg/kg. Chromium (38.2 mg/kg) exceeded its ESL of 26 mg/kg at one location at SWMU 40, which slightly exceeded its background level of 31 mg/kg. Cobalt (15.8 mg/kg) exceeded its ESL of 13 mg/kg at two locations at SWMU 35, but not its background level of 17 mg/kg. Lead (16.8 J to 43.9 J) exceeded its ESL of 11 mg/kg at five SWMUs (one location at SWMU 3, one location at SWMU 34, two locations at SWMU 36, one location at SWMU 39, and two locations at SWMU 40). The lead ESL exceedances were below the background level of 32 mg/kg at SWMUs 34 and 39, at one location at SWMU 36, and at one location at SWMU 40. Nickel (49.1 and 233 mg/kg, respectively) exceeded its ESL of 13.6 mg/kg at two locations at SWMU 39 and at two locations at SWMU 40. The nickel ESL exceedance at one location at SMWU 39 was below the background level of 28 mg/kg. Vanadium (27 to 577 mg/kg) exceeded its ESL of 7.8 mg/kg at all eleven SWMUs.

However, vanadium did not exceed its background level of 139 mg/kg, except for the two locations (466 and 577 mg/kg) at SWMU 40.

- The results of the sediment sampling for VOCs and PAHs at Lajas Creek show that only acetone was detected. Acetone (19.9 ug/kg) exceeded its ESL of 9.9 ug/kg. However, acetone is a common laboratory contaminant, and its detection is likely due to a laboratory artifact unrelated to site conditions.
- The results of the surface water sampling for VOCs and BNAs at Lajas Creek show that no VOCs or BNAs were detected. The results of the surface water sampling for VOCs, BNAs, and metals at the Main Dock Sump (SWMU 33) show that no VOCs or BNAs were detected, and that no metals exceeded ESLs.

Interim Measures

- FPH was observed on the water table at the following five SWMUs: East API Separator (SWMU 3), the Watery Oil Separator (SWMU 43), the Main Dock Sump (SWMU 33), the Barge Dock Sump (SWMU 34), and Northeast Refinery Area (SWMU 40). Residual product was also observed in the soil at limited sections of the East Aisle Ditch (SWMU 45).
- The FPH plumes are of localized extent and appear to be stable or shrinking. Chemical fingerprinting data indicate that the product is generally old and severely degraded.
- At all six areas, interim measures were implemented in 1997 and are ongoing. The interim measures consist of monitoring of FPH levels and FPH removal using bailers on a weekly and/or quarterly schedule from affected wells. Results are reported in RFI quarterly progress reports.

Conclusions

- RFI objectives have been achieved at all sixteen SWMUs. Characterization and delineation of any contamination is complete.
- Based on the results of the RFI as described above, the RFI has been completed and no further investigation or interim measures are warranted at the following ten SWMUs:
 - Slop Oil Tank (SWMU 35)
 - Dissolved Air Flotation Unit (SWMU 36)
 - Dewatering Chamber (SWMU 38)
 - Hazardous Waste Mixing Box (SWMU 39)
 - Ballast Basin Skimmer Area (SWMU 44)
 - Ballast Basin Leachate Collection Tank (SWMU 44A)
 - West API Separator (SWMU 2)
 - Final Retention Basin (SWMU 14)
 - North Aeration Basin (SWMU 17)
 - South Aeration Basin (SWMU 18)
- At six SWMUs, the RFI has been completed, no additional investigation is warranted, and interim measures have been implemented to address the presence of FPH on the water table. FPH monitoring and/or recovery for interim measures will continue at these SWMUs. At the Main Dock Sump, groundwater monitoring at well MDS-4 will also continue. The FPH and groundwater results will be reported to EPA in RFI quarterly reports.
 - Northeast Refinery Area (SWMU 40)
 - Watery Oil Separator (SWMU 43)
 - Main Dock Sump (SWMU 33)
 - Barge Dock Sump (SWMU 34)
 - East Aisle Ditch (SWMU 45)
 - East API Separator (SWMU 3)

9.0 References

Anderson, Mulholland & Associates, Inc. (AMAI), 1994, RCRA Facility Investigation: Description of Current Conditions, Puerto Rico Sun Oil Company, Yabucoa, Puerto Rico.

Anderson, Mulholland & Associates, Inc. (AMAI), 1994, RCRA Facility Investigation Work Plan, Puerto Rico Sun Oil Company, Yabucoa, Puerto Rico.

Anderson, Mulholland & Associates, Inc. (AMAI), 1997, Process Sewer Assessment Report, Puerto Rico Sun Oil Company, Yabucoa, Puerto Rico.

Caribbean Fisheries Management Council, 1991, The State of Puerto Rican Corals: an Aid to Managers.

Geraghty & Miller, 1985, Preliminary Ground Water Exploration Program in the Plant Process Area, Yabucoa Sun Oil Company, Yabucoa, Puerto Rico.

Geraghty & Miller, 1987, Results of a Ground Water Exploration Program and the Installation of Test Well 4 for the Yabucoa Sun Oil Company.

Geraghty & Miller, January 1991, Evaluation of the RCRA Facility Assessment Report, Puerto Rico Sun Oil Company Refinery, Yabucoa, Puerto Rico.

National Oceanic and Atmospheric Administration (NOAA), 2000, Environmental Sensitivity Map, Punta Guayanés, Puerto Rico, Map PR-54.

Puerto Rico Environmental Quality Board (EQB), March 2003, Puerto Rico Water Quality Standards Regulation, Article 3.

Testa, Stephen M. and Winegardner, Duane L., 1991, Restoration of Petroleum-Contaminated Aquifers, Lewis Publishers, 269 p.

Texas Natural Resource Conservation Commission, March 2006, Protective Concentration Levels (PCLs), Texas Risk Reduction Program.

Turekian, K.K., 1968, Oceans, Prentice Hall, New York.

U.S. Environmental Protection Agency (EPA), 1988, Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Data Analyses.

U.S. Environmental Protection Agency (EPA), 1991, Contract Laboratory Program, National Functional Guidelines for Organic Data Review. OLM01.0 and OLC01.0.

U.S. Environmental Protection Agency (EPA), Region 2, 1992a, Contract Laboratory Program, Organic Data Review Standard Operating Procedure No. HW-6, Revision 8.

U.S. Environmental Protection Agency (EPA), Region 2, 1992b, Evaluation of Metals Data for the Contract Laboratory Program (CLP) Standard Operating Procedure No. HW-2, Revision 11.

U.S. Environmental Protection Agency, 1996, Soil Screening Guidance: Technical Background Document. EPA/540/R-95/128.

U.S. Environmental Protection Agency (EPA), 1997, Ecological Risk Assessment Guidance for Superfund, Process for Designing and Conducting Ecological Risk Assessments, Interim Final, EPA 540-R-97-006.

U.S. Environmental Protection Agency (EPA), 1998, Guidelines for Ecological Risk Assessment, EPA/630/R-95/002F.

U.S. Environmental Protection Agency (EPA), 2001, The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments, Intermittent Bulletin, EPA 54/F-01/014.

U.S. Environmental Protection Agency (EPA), 2002a. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

U.S. Environmental Protection Agency (EPA), 2002b, National Recommended Water Quality Criteria, Office of Water, Office of Science and Technology, EPA-822-R-02-047.

U.S. Environmental Protection Agency (EPA), Region 5, 2003a, Ecological Screening Levels.

U.S. Environmental Protection Agency (EPA), Region 4, 2003b, Ecological Risk Assessment Bulletins, Supplement to RAGS.

U.S. Environmental Protection Agency (EPA), Region 3, October 2006, Risk Based Concentration Table, Office of RCRA Technical & Program Support Branch.

U.S. Environmental Protection Agency (EPA), Region 9, October 2004, Preliminary Remediation Goals (PRGs).

U.S. Environmental Protection Agency (EPA), 2004c, Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final, EPA/540/R/99/005, OSWER 9285.7.

U.S. Environmental Protection Agency (EPA), 2005, Guidance for Developing Ecological Soil Screening Levels, OSWER Directive 9285.7-55.

U.S. Environmental Protection Agency (EPA), 2006, Ecological Soil Screening Levels, <http://www.epa.gov/ecotox/ecossl>, last updated on May 4, 2006.

U.S. Fisheries and Wildlife Service (USFWS), March 2005, Wetlands Online Mapper, at <http://wetlandsfws.er.usgs.gov/wtlnds/>.

U.S. Geological Survey, 1994, Water Resources Data, Puerto Rico and the U.S. Virgin Islands, Water Year 1993 - Water Data Report PR-93-1.

U.S. Geological Survey, 1996a, Geochemical Properties and Saline-Water Intrusion in the Valle de Yabucoa Alluvial Aquifer, Southeastern Puerto Rico, Water-Resources Investigations Report 94-4188.

U.S. Geological Survey, 1996b, Atlas of Ground-Water Resources in Puerto Rico and the U.S. Virgin Islands, Water-Resources Investigations Report 94-4198.

U.S. Geological Survey (USGS), 1998, Status and Trends of the Nations Biological Resources, U.S. Department of the Interior, USGS, Reston, VA.

University of Puerto Rico, Department of Marine Sciences, 1970. A Synoptic Base-Line Study of Yabucoa Bay, Puerto Rico, for the Sun Oil Company.

World Health Organization (WHO), 2001, Arsenic and Arsenic Compounds, 2nd Edition, Geneva.

Yabucoa Sun Oil Company, 1985, Part B Hazardous Waste Permit Application.